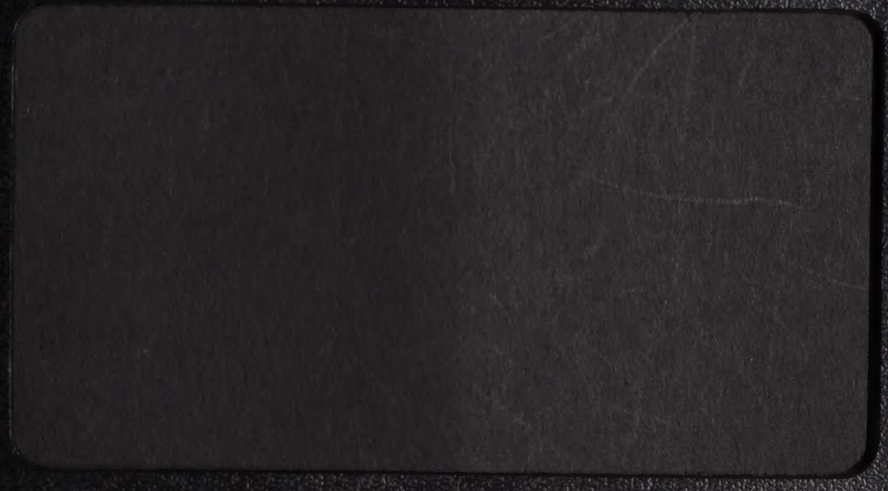

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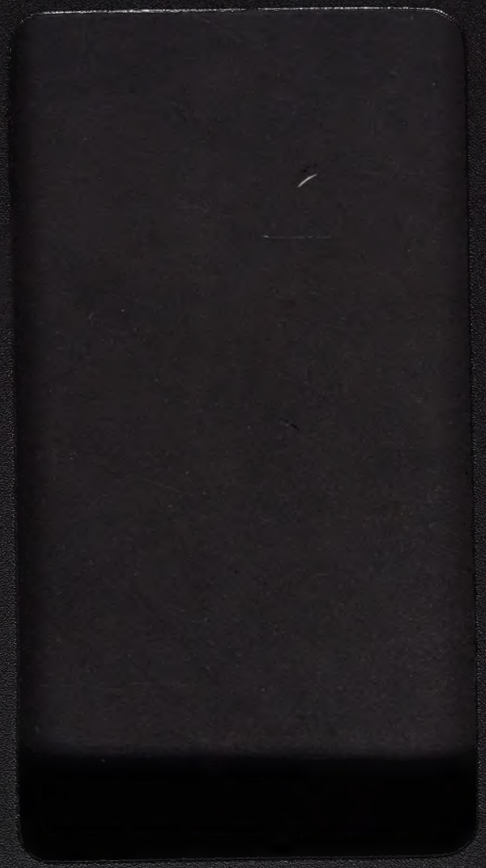

SERIAL 130 D

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INSTRUCTION MANUAL

SD301D-C
REAL TIME ANALYZER

(MODIFIED TO MODEL SD301D-C-12B)

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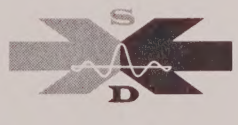

Spectral Dynamics

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MODEL SD301D-C REAL TIME ANALYZER

ADDENDUM
Model SD301D-12B Real Time Analyzer

The Model SD301D-12B is basically a standard SDC Model SD301D Real Time Analyzer. The "-12B" in the model number denotes the following modifications to the basic unit:

a. Digitized outputs of the SPECTRUM LIN STEP and the SPECTRUM LOG outputs are available at RTA connector J15. The output to be digitized is remotely selected by a LIN SPECTRUM SELECT signal inputted to RTA connector J15 Pin 26. A 12-bit binary word is simultaneously outputted with each frequency step (cell location) of the selected output signal.

b. A 40 microsecond FRAME SYNC pulse, which precedes each RTA analysis sweep is outputted to the remote control unit via connector J15 Pin 17.

c. A 40 microsecond WORD SYNC pulse, which accompanies each outputted digital word, is outputted to the remote control unit via connector J15 Pin 1.

d. A MEMORY PERIOD SYNC mode can be activated by the remote control unit via J15-19. In this mode, the digitized output is available at J15 for the first analysis sweep of the RTA that follows the completion of each input memory refresh cycle (1500 data points loaded) and is not available again until the completion of another input memory refresh cycle.

The 12-Bit A/D Converter Circuit Card, Assembly No. 10154900, has been installed in receptacle XA30 formerly used to store the Extender Circuit Card. The schematic for this circuit, number 10154800, is included in this addendum. Pin functions for RTA connector J15 are given in Figure 7 and interconnect information is given in Figure 8. Calibration for the 12-Bit A/D Converter Circuit is given in this addendum.

THEORY OF OPERATION

The 0V to 5V SPECTRUM LIN STEP signal is selected by application of a high to LIN SPECTRUM SELECT (Pin A30-H) from the remote control unit via J15-26. The 0V to 1V SPECTRUM LOG signal is selected for digitizing by application of a low to LIN SPECTRUM SELECT (Pin A30-H). See Figure 1, A/D Converter Circuit Block Diagram and Figure 2, Word Timing Diagram. The selected signal input is gated into the A/D Converter. After A/D conversion, the digits are outputted in parallel to the output buffers. At the end of conversion, a WORD

SYNC pulse of 40 microseconds duration is outputted to the remote control unit via J15-1. The 12-bit word is transferred in parallel to the remote control unit from the output buffers via J15 pin connections which are given in Figure 7.

During retrace blanking of the RTA analysis sweep, a RETRACE BLANKING pulse from Scan unit (A27-19) is inputted to inhibit the MEMORY SYNC and the START CONVERSION pulses for the duration of retrace blanking. Timing diagrams for the three Sweep Initiation control settings are given in Figures 3 through 5. At the end of the RTA sweep a 40 microsecond FRAME SYNC pulse is outputted to the remote control unit via J15-17 to signal the start of a new analysis sweep.

The remote control unit may select a MEMORY PERIOD SYNC mode by application of a ground via J15-19 at Pin A30-X. This signal allows the A/D conversion process to be controlled by the SAMPLE COUNTER RECYCLE (Pin A30-17) and RETRACE BLANKING (Pin A30-20) pulses. The timing diagram for the MEMORY PERIOD SYNC mode is given in Figure 6.

CALIBRATION

The following procedure should be used to calibrate the 12-Bit A/D Converter Circuit (A30).

a. Be sure power is OFF; remove the instrument top cover. Remove detector circuit card A29 and temporarily lay it aside.

b. Lift out ADC circuit card A30, unsolder and lift off the jumper wire at A30E1. Replace A30 in its receptacle.

c. Lift out the output amplifier circuit card A21, connect a jumper between A21TP1 and A21TP9. Replace A21 in its receptacle. (If A21TP9 is not present, connect jumper between A21TP1 and the junction of resistors A21R2 and A21R6.)

d. Apply power and allow a 15 minute warmup.

e. Adjust potentiometer A30R39 (CLOCK ADJUST) for a 25 microsecond positive going pulse at A30TP9.

f. Set FREQUENCY-CAL control to LIN ZERO.

g. Adjust A30R17 (LIN ZERO) for a digital word output of all "0's"; that is, between 0V and 0.2V at the appropriate pins of rear-chassis connector J15. See Figure 7.

h. Set the FREQUENCY-CAL control to FULL SCALE.

i. Adjust A30R36 (LIN GAIN) for a digital word output of all "1's"; that is, a nominal 3V at each of the appropriate pins of J15. See Figure 7.

j. Repeat Steps f. through i. to compensate for interaction.

k. Ground Pin 26 of J15 (LIN SPEC SELECT).

l. Set FREQUENCY control to LIN ZERO.

m. Adjust A30R19 (LOG ZERO) for a digital word output of all "0's"; that is, between 0V and 0.2V at the appropriate pins of rear-chassis connector J15. See Figure 7.

n. Set the FREQUENCY-CAL control to FULL SCALE.

o. Adjust A30R35 (LOG GAIN) for a digital word output of all "1's"; that is, a nominal 3V at each of the appropriate pins of J15. See Figure 7.

p. Repeat Steps l. through o. to compensate for interaction.

q. Remove power, remove jumper between A21TP1 and A21TP9, and replace A21 in its receptacle.

r. Lift out ADC circuit card A30, resolder jumper at A30E1, and replace A30 in its receptacle.

s. Replace detector circuit card A29 in its receptacle.

t. Apply power to the instrument and check the ADC timing per Figures 2 through 6.

u. Remove power, replace instrument top cover, and place instrument in service.

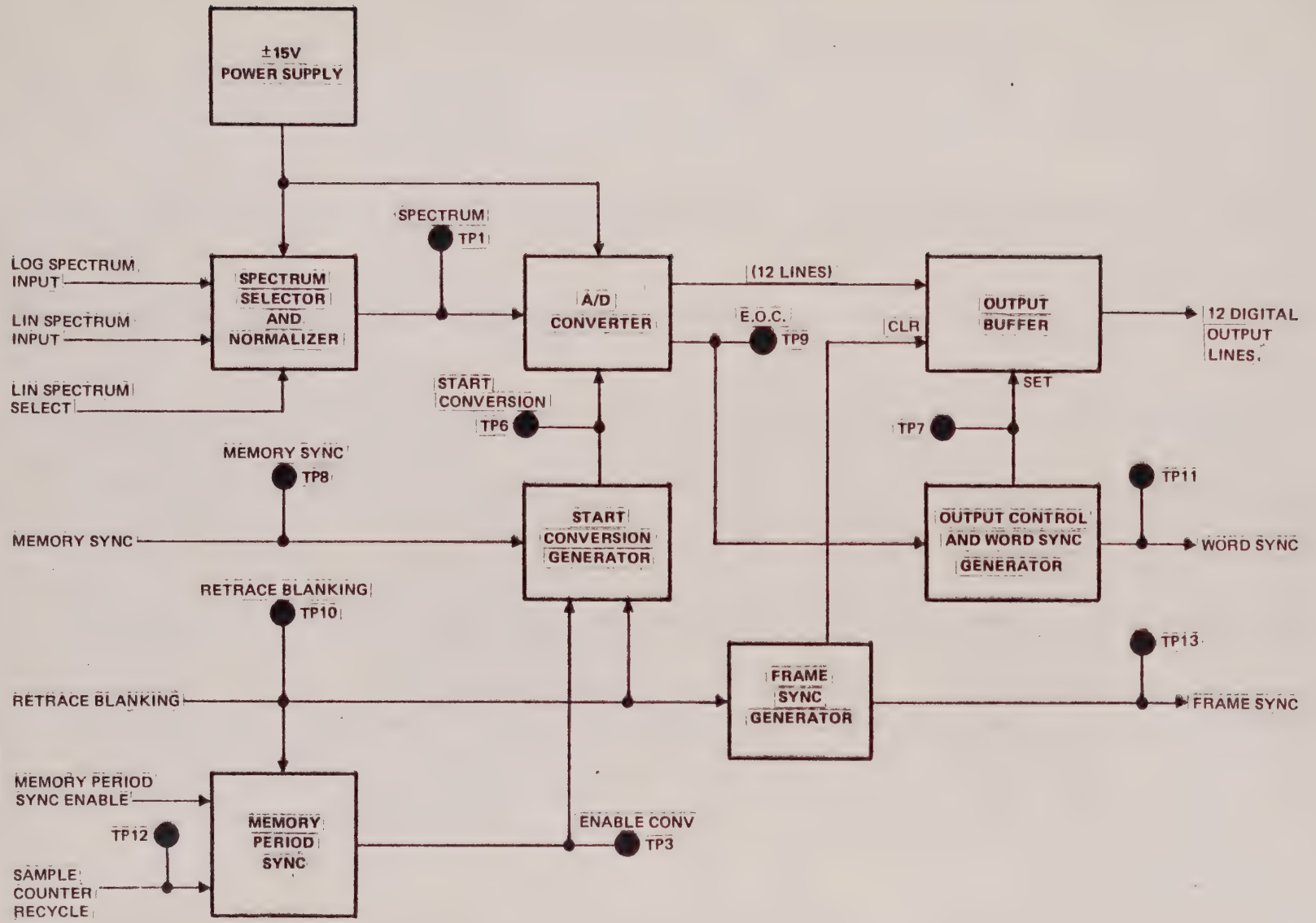


Figure 1. Block Diagram 12-Bit A/D Converter (A30)

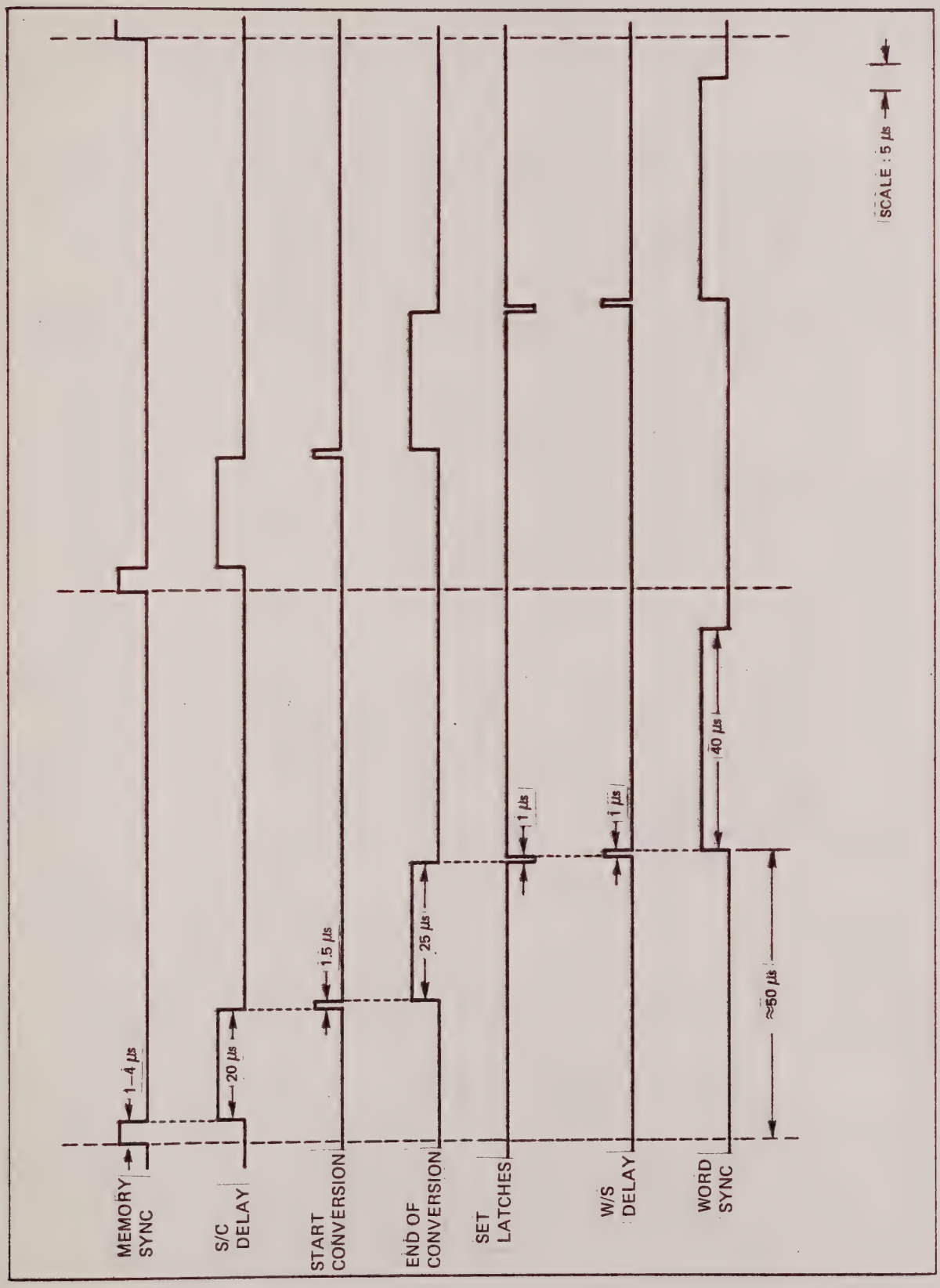


Figure 2. Word Timing for the 12-Bit A/D Converter Circuit

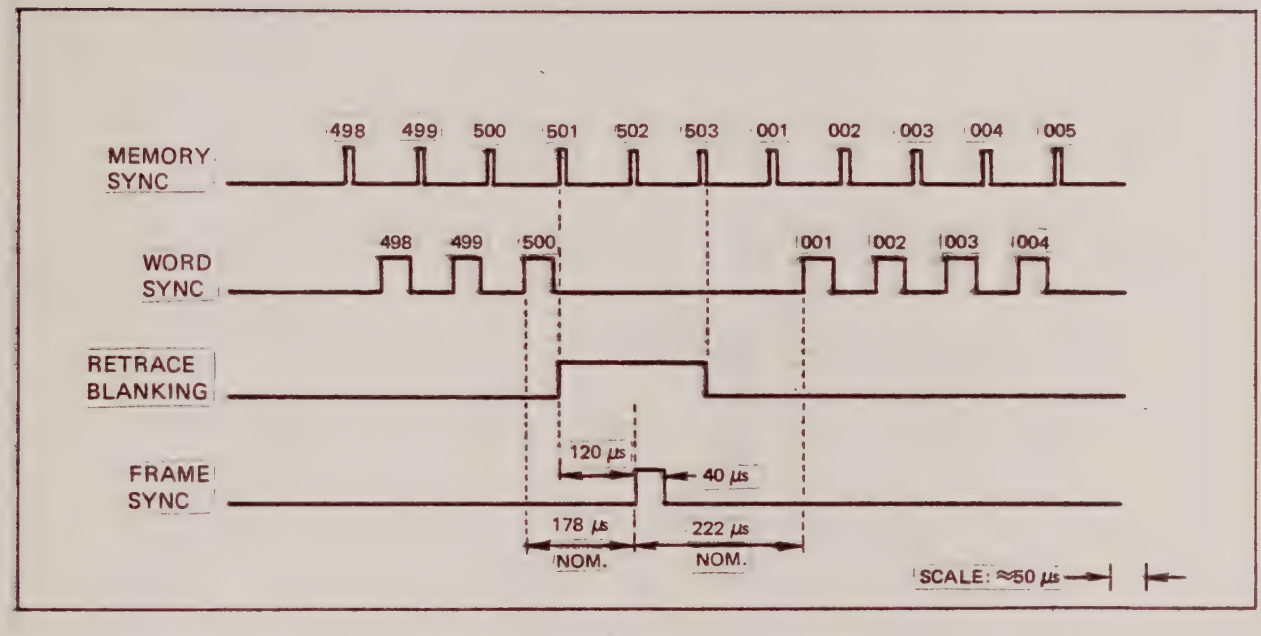


Figure 3. Frame Timing Auto Mode

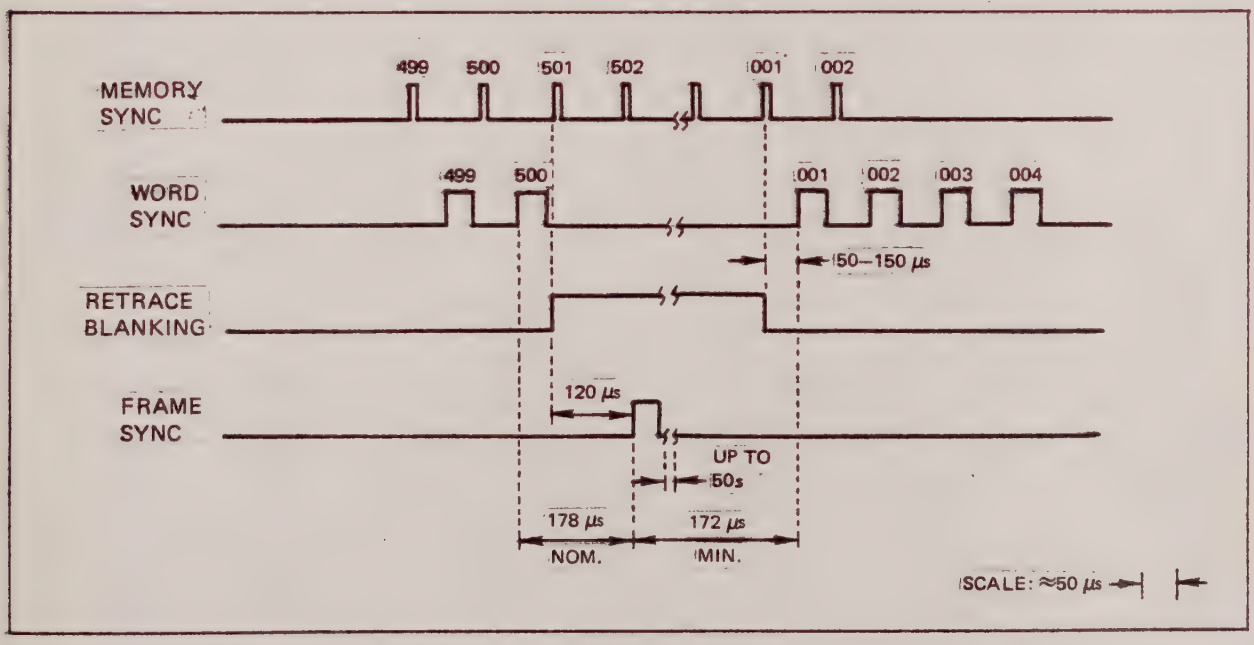


Figure 4. Frame Timing Memory Period Mode

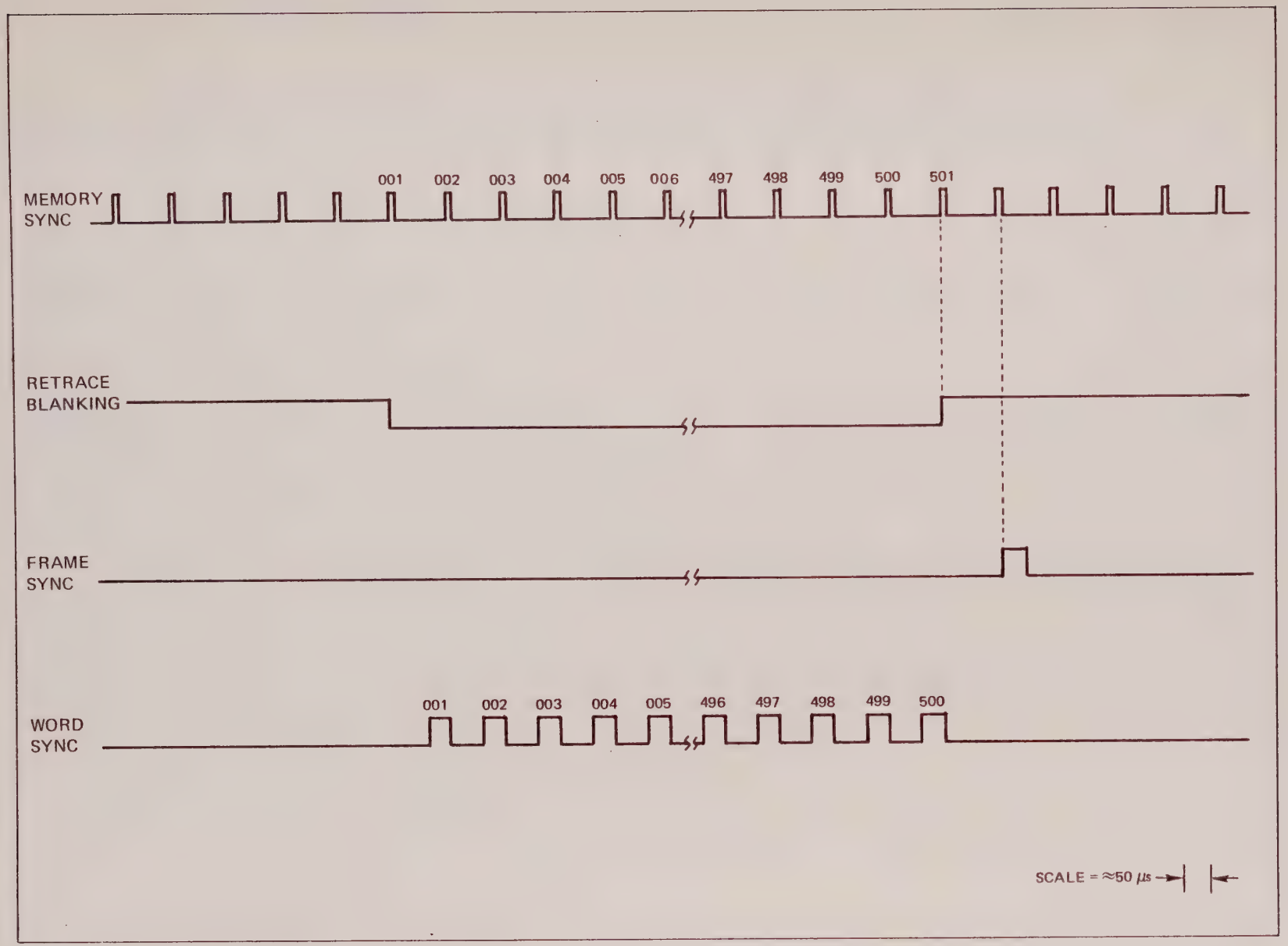


Figure 5. Frame Timing Single Reset Mode

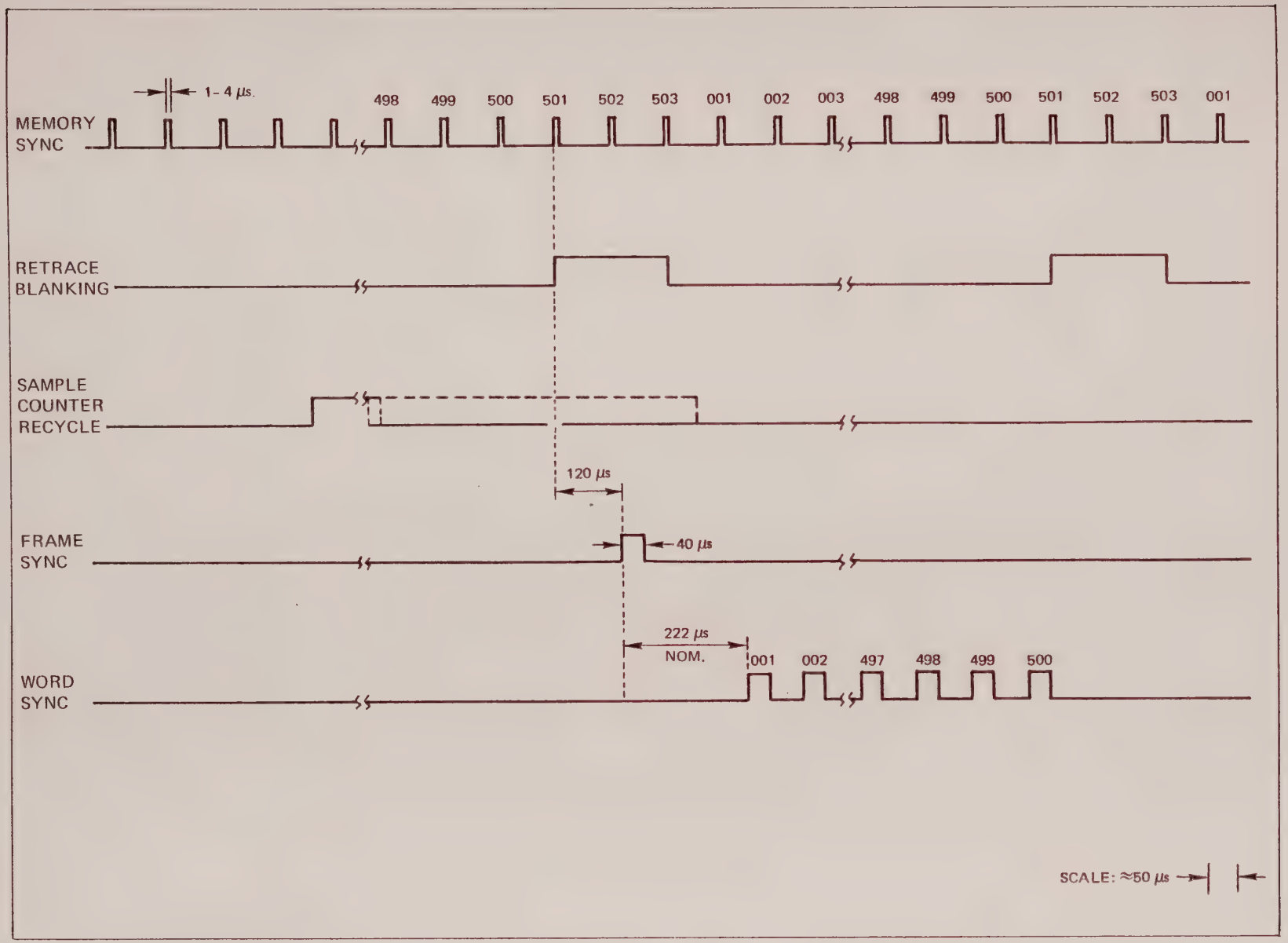


Figure 6. Frame Timing Memory Period Sync Mode

J15 Pin Number	J15 Function
26	LIN SPECTRUM SELECT Input
19	MEMORY PERIOD SYNC ENABLE Input
17	FRAME SYNC Output
1	WORD SYNC Output
3	Bit 1 (MSB) Output
4	Bit 2 Output
5	Bit 3 Output
6	Bit 4 Output
9	Bit 5 Output
11	Bit 6 Output
12	Bit 7 Output
14	Bit 8 Output
15	Bit 9 Output
16	Bit 10 Output
24	Bit 11 Output
25	Bit 12 (LSB) Output

Figure 7. Connector J15 Pin Functions

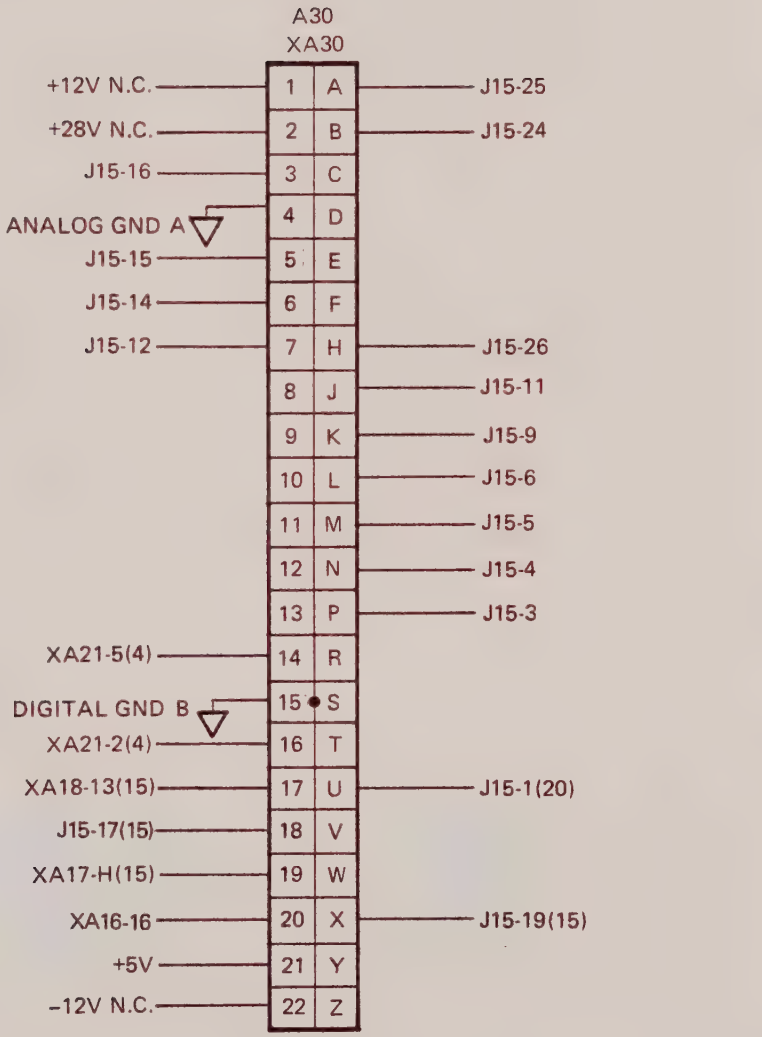
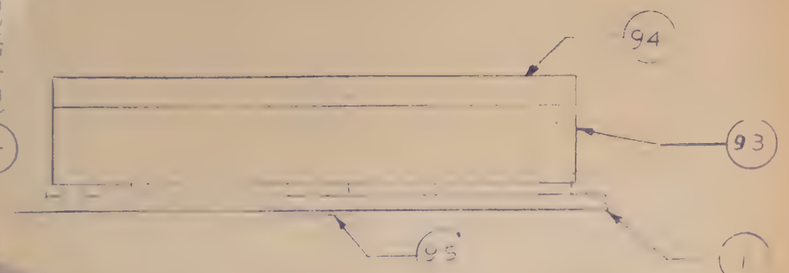
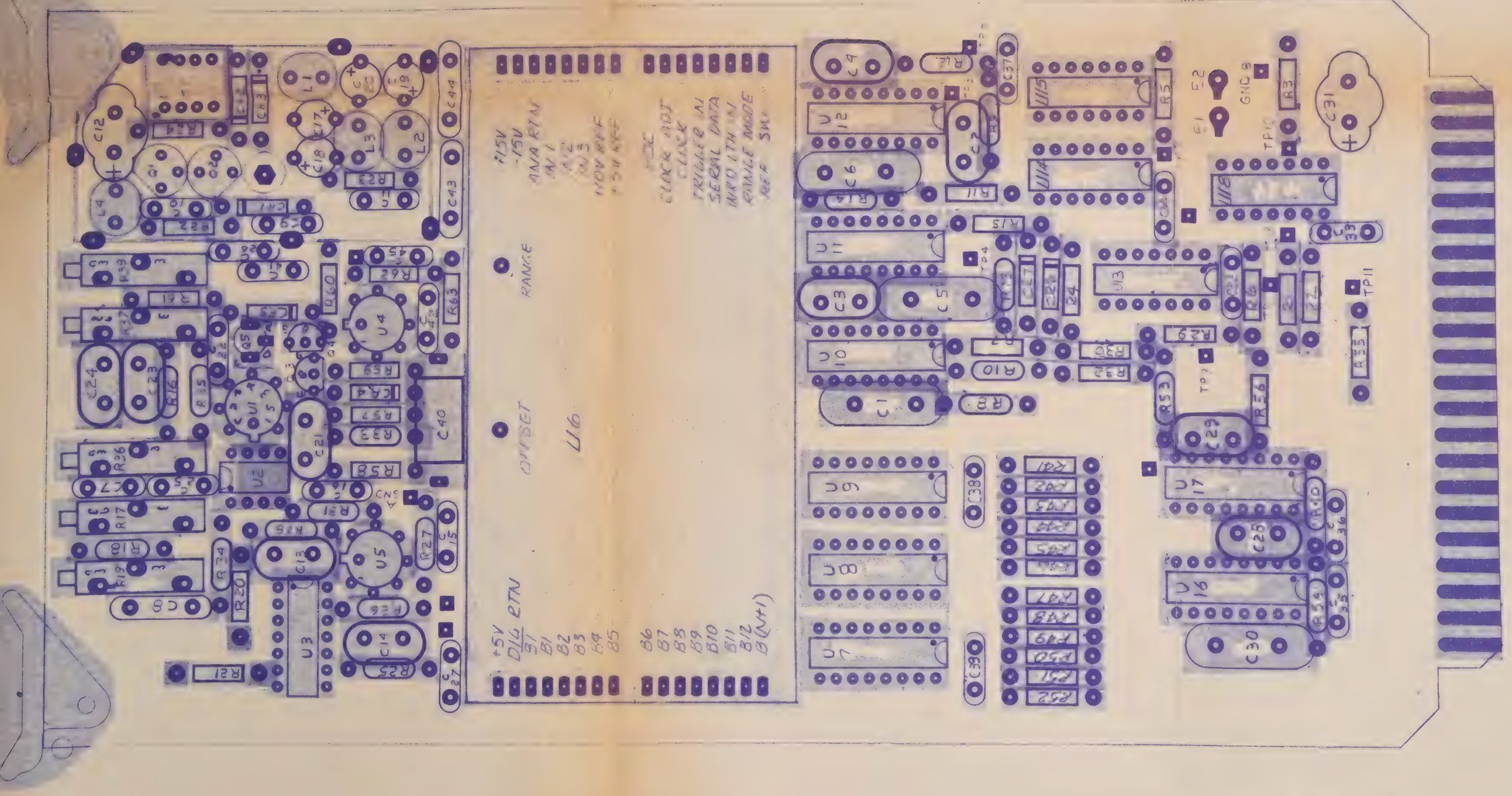
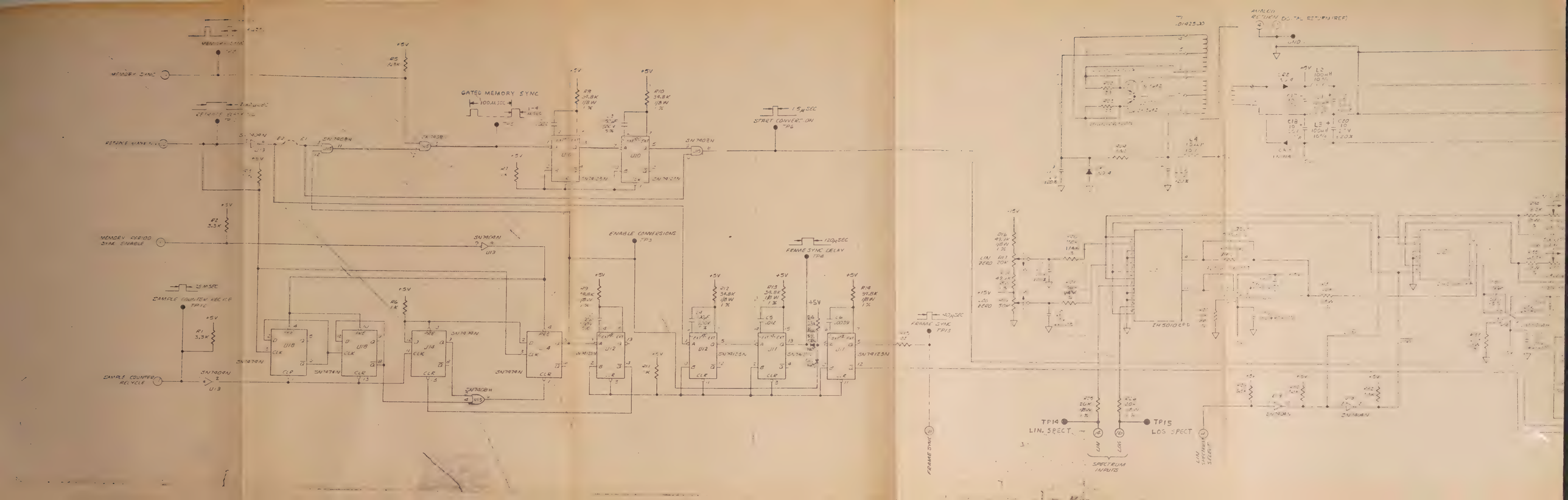


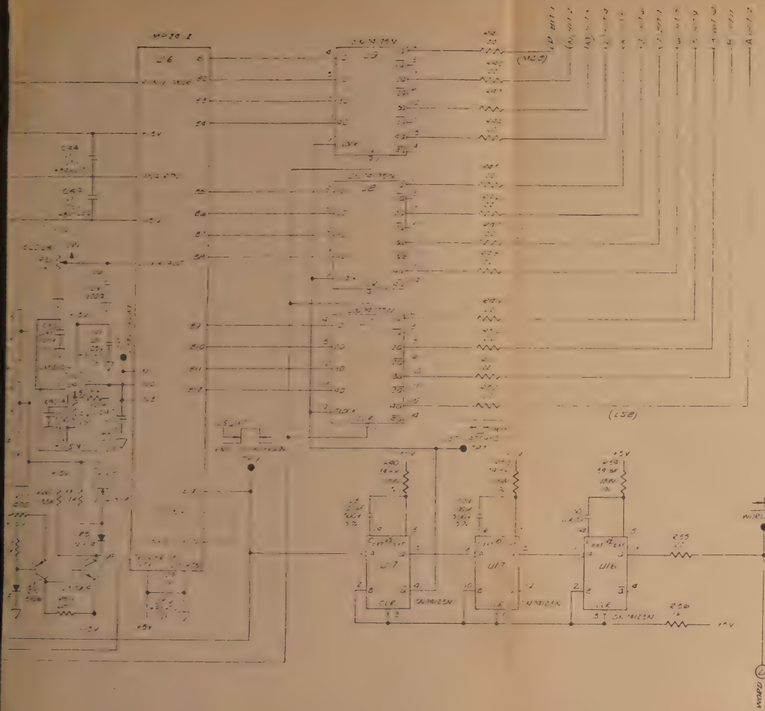
Figure 8. Interconnect for A/D Converter (A30)
Amends Main Frame Interconnect Diagram

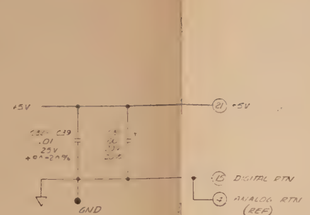


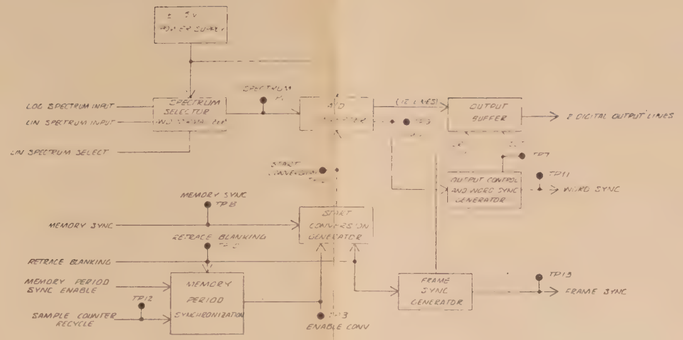


SPECTRAL DYNAMICS CORPORATION OF SAN DIEGO	TITLE PC ASSY-12 BIT OUTPUT A/D CONVERTER		SIZE C	MODEL NO. SD301C/D-12B	
	DRAWN	8-29-73	DRAWING NO. 10159900	REV D	
	CHECK	9/19/73			
	ENGR	9-14-73			
	APPR		SHEET OF 6		


MEMORY SYNC
RETRACE BLANKING
GATED MEMORY SYNC
100 μSEC
START CONVERSION
1.5 μSEC
ENABLE CONVERSIONS
TP3
FRAME SYNC DELAY
120 μSEC
FRAME SYNC
TP13
SAMPLE COUNTER RECYCLE
TP12
MEMORY PERIOD SYNC ENABLE
TP14
LIN. SPECT.
TP15
LOG SPECT.
SPECTRUM INPUTS
ANALOG RETURN (DIGITAL RETURN/REF)
LIN. ZERO
LOG ZERO
SN7400N
SN7402N
SN7408N
SN7474N
SN74123N
SN74121N
SN74H01CD







BLOCK DIAGRAM
12 BIT OUTPUT A/D CONVERTOR

| | | |

MANUAL CHANGES

Model: SD301D-C
Unit Serial: All
Manual Edition: _____

Each change listed below must be individually analyzed for applicability in accordance with "Action" directed relative to unit serial number and/or documentation affected.

Change #1

Because a linear stepped spectrum output is required for operation of the Model SD301D-C RTA with a Model 13151 "Waterfall" Display Control unit, all SD301D-C units from S/N107 on incorporate the following change to rear-panel BNC connector, J19:

Units below S/N107 have this change only when they have been especially modified for operation with the Model 13151.

MANUAL CHANGES

Model: SD301D and SD301D-C
Unit Serial: 516 and 097 respectively
Manual Edition: _____

Each change listed below must be individually analyzed for applicability in accordance with "Action" directed relative to unit serial number and/or documentation affected.

Change #1

Page 4-8, paragraph 4.2.5.1. Change steps f. and g. as follows:

f. On circuit card A26, turn A26R2 (RTA Baseline Clamp) fully ccw, and change jumper from between A21TP1 and A21TP9 to A21TP1 and A21TP2.

g. Perform steps c.1. through c.5. while monitoring A26TP2; then remove jumper between A21TP1 and A21TP2.

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DWG.NO.	DESCRIPTION
10184200	High Speed D/A, Circuit Card A1
10184300	Clock, Circuit Card A2
10184400	Memory, Circuit Card A3-11
10324100	Digital Indicator, Circuit Card A12
10208000	A/D Converter, Circuit Card A13
10184900	Display Control, Circuit Card A16
10185000	Counter Control, Circuit Card A17
10221300	Marker Generator, Circuit Card A18
10185200	Counter, Circuit Card A19
10185300	BCD Ladder, Circuit Card A20
10229300	Output Ampl, Circuit Card A21
10185500	Sweep, Circuit Card A22
10185600	Cursor Position, Circuit Card A23
10185700	Signal Multiplexer and dB Encoder, Circuit Card A24
10185800	18–23 MHz VCO, Circuit Card A25
10185900	Mixer & RTA Output Ampl, Circuit Card A26
10186000	Scan Unit, Circuit Card A27
10330700	Down Converter, Circuit Card A28
10186200	Detector, Circuit Card A29
10186300	Power Supply, Circuit Card A33
10186400	Numeric Indicator, Circuit Card A37
10180600	Sheet 1 - Front Panel Interconnect Sheet 2 - Input, Circuit Card A32 Sheet 3 - Remote Control, Circuit Card A36
10180500	Main Frame Interconnect
10446500	Cable Assembly, SD301A, B, C, D/-C

PREFACE

RECEIVING INSPECTION PROCEDURE

The Model SD301D-C Real Time Analyzer is shipped fully assembled, packed in a polystyrene case designed to protect it against all normal shipping hazards. Immediately upon receipt, inspect the exterior of the shipping case and note any visible damage. Keep all forms and invoices attached to the shipping case. Remove the instrument from the shipping case and test its functional operation. If shipping damage is apparent, file a claim with the carrier's claims agent and send a copy to Spectral Dynamics Corporation. Be sure to include the instrument name, model number, and serial number on all correspondence. Spectral Dynamics Corporation will advise the buyer what should be done; arrangements for repair or replacement will be made as applicable.

WARRANTY POLICY

All Spectral Dynamics products are warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery, or, in the case of certain components listed in some of the operating manuals, for the specified period. We will repair or replace products which prove to be defective during the warranty period, providing the failure or damage has not been caused by misuse or abnormal operating conditions. Fuses and lamps are specifically excluded from warranty. If the malfunction or a portion thereof is determined by Spectral Dynamics Corporation to have been caused by misuse or abnormal conditions of operation, an estimate of cost to repair will be submitted to the purchaser for approval before beginning any repair work.

Liability under this warranty is limited to servicing and adjusting the instrument returned to the factory, with transportation charges prepaid by the purchaser. No other warranty is expressed or implied. We are not liable for consequential damages.

If any malfunction develops, notify Spectral Dynamics Corporation or its representative in your area, giving details of the problem, and the name, model and serial number of the equipment. Upon receipt of this information, service data or shipping instructions will be provided.

RETURN SHIPMENT PROCEDURE

On receipt of shipping instructions, forward the instrument prepaid via air freight to the factory or authorized repair station indicated on the instructions. Replace the instrument in its original shipping case, or surround with two or three inches of shock absorbing material and then pack it in a heavy-weight cardboard box, wooden box, or other strong container.

SECTION I
GENERAL INFORMATION

1.1 INTRODUCTION

The Real Time Analyzer (RTA) performs a Fourier analysis of audio and vibration data in ten analysis ranges which provide filter spacings as narrow as .02 Hz and analysis frequencies as high as 50 kHz. Frequencies up to 10 kHz may be analyzed with no loss of input data which allows the operator to observe "on-line" the spectrum content of a signal from a test or process. The RTA provides rapid signal analysis, immediate diagnosis of existing conditions, or observation of cause and effect as a part or process is changed.

The RTA can accept and follow a predetermined external sampling rate or lock its sampling characteristic to some variable frequency phenomena. The operator has control over location of data in memory for accurate automatic transient analysis of signals with the number of words loaded into memory displayed in the LED readout. The RTA provides calibrated amplitude displays with digital readout of spectrum amplitude and calibrated frequency displays with digital readout of exact frequencies.

The RTA output spectrum amplitude and frequency may be either linear or log and may be observed on an oscilloscope, plotted on an X-Y recorder or displayed in a variety of 3-dimensional forms in real time. By combining the RTA with an Ensemble Averager and a Memory, the RTA display becomes more versatile. With these units the operator may present two spectra simultaneously on the same oscilloscope for direct visual comparison. The two spectra can be brought closer together or separated at will, even overlaid. With the Cursor Locator, the operator can position an intensity dot on any spectral peak for precise identification on the LED readout of that peak's frequency or amplitude.

This dual display mode permits observing simultaneously various combinations of the real time spectra, a spectrum average in progress and a stored spectra in either linear or log format. See Figure 1-1 for a RTA setup for a typical application.

Standard accessory units are available for spectrum averaging, spectrum storage, normalization of spectra from rotating machinery, conversion of narrowband data to equivalent 1/3 octave spectra, narrowband spectrum translation, simplified balancing/spectral analysis, spectrum line tracking and many other functions. Section II gives application information for the RTA with a complete list of accessory units.

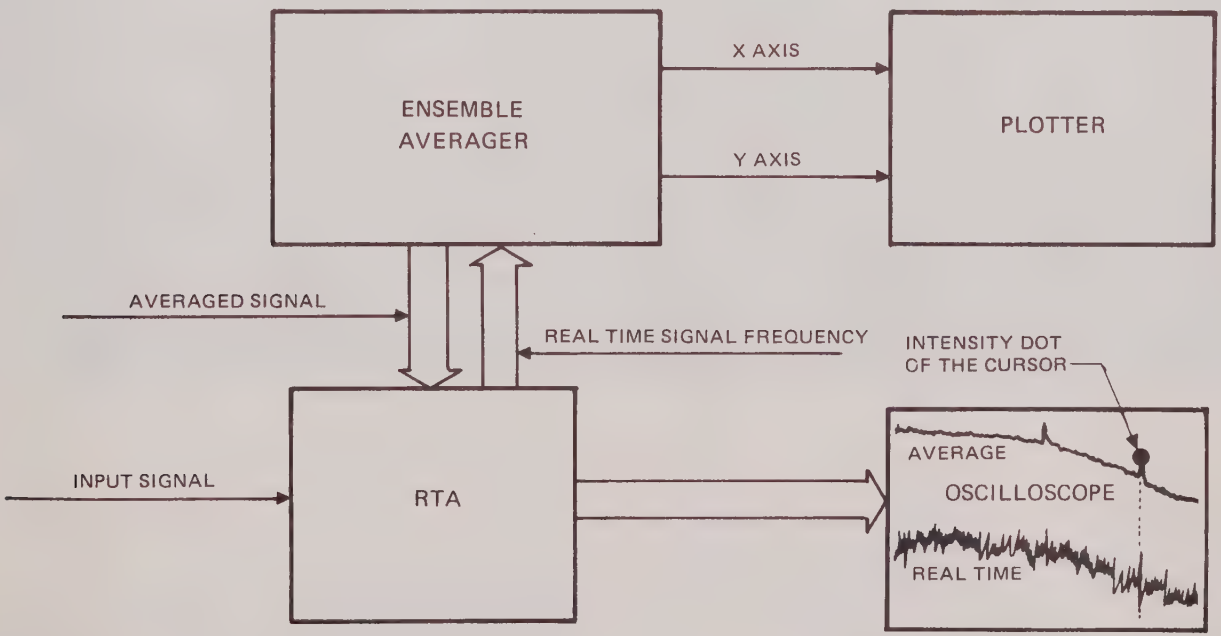


Figure 1-1. RTA Setup for Typical Application

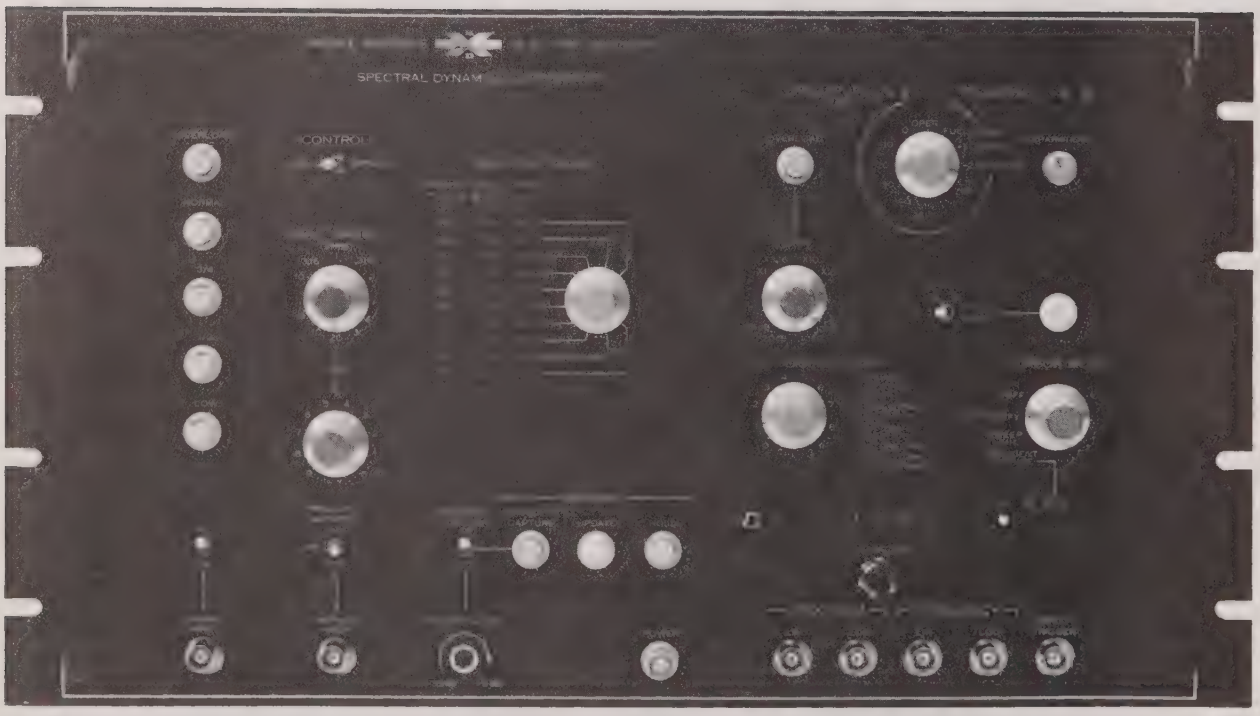


Figure 1-2. Front Panel

1.2 FRONT PANEL FUNCTIONAL DESCRIPTION

Controls and connectors located on the front panel are described in the following groups according to their function: Input, Analysis Range, Memory Mode/Transient Capture, Output Operate Mode, Output Mode, Outputs and Power. Front-panel controls are shown in Figure 1-2.

1.2.1 Input Group

1.2.1.1 Input Level Indicators

OVERLOAD Indicator (DS8)
Lights when input signal is full scale or exceeding full scale of range selected. When lighted, distortion could be present. Lights when any in-band or out-of-band input overload condition is detected.

NORMAL Indicator (DS7)
Lights when input signal is approximately 1 dB less than full scale of range selected.

3/4 Indicator (DS6)
Lights when input signal is ≈75% full scale, or ≈3 dB below full scale of range selected.

1/2 Indicator (DS5)
Lights when input signal is ≈50% full scale, or ≈6 dB below full scale of range selected.

LOW Indicator (DS4)
Lights when input signal is ≈25% full scale, or ≈12 dB below full scale of range selected.

1.2.1.2 INPUT RANGE (Vrms) (S2)

Coarse and fine range attenuator controls provide 0 to 49 dB attenuation of the input signal in 1 dB steps. The total attenuation equals the sum of both control settings.

Coarse INPUT RANGE attenuator control selects input signal range 0.1 Vrms to 10 Vrms in 10 dB steps.

Fine INPUT RANGE attenuator control provides 9 dB range in 1 dB steps to give complete coverage between the 10 dB steps of the coarse control. The Fine attenuator also controls the SPECTRUM-CAL signal when selected.

1.2.1.3 AC/DC Control (S8) SIGNAL INPUT Connector (J45)

AC/DC control selects either direct-coupled (DC) input circuit to provide flat frequency response for low frequency signals, or an a-c coupling (AC) circuit to block a d-c level that might be present on the input signal.

SIGNAL INPUT connector accepts signal to be analyzed; is connected in parallel with J24, SIGNAL INPUT, on the rear chassis and J38 internally.

1.2.1.4 FREQUENCY MARKERS Control/ MARKER INPUT Connector (J46)

FREQUENCY MARKERS Control (S7)

INT
Applies 10 equally-spaced frequency markers to the output spectrum, approximately 26 dB down from full scale.

OFF
No markers are applied to output spectrum display.

EXT
Externally applied markers are summed with the input signal to provide output spectrum frequency-reference markers.

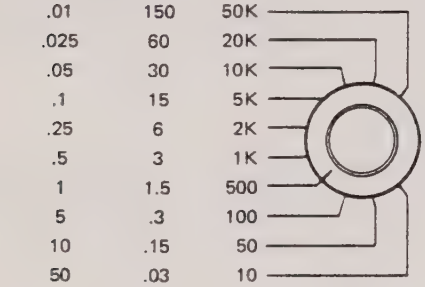
MARKER INPUT (J46)

Accepts external signals to be used as spectrum frequency-reference markers. Input impedance is 5k ohms nominal. A 1 Vrms input provides marker display at approximately 20 dB down from full scale. This connector is connected in parallel with J23, MARKER INPUT, on the rear chassis and J40 internally.

1.2.2 ANALYSIS RANGE (S1)

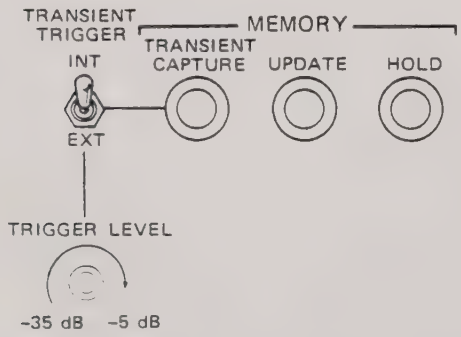
ANALYSIS RANGE

MEMORY PERIOD SEC	BAND WIDTH HZ	UPPER LIMIT HZ
.01	150	50K
.025	60	20K
.05	30	10K
.1	15	5K
.25	6	2K
.5	3	1K
1	1.5	500
5	.3	100
10	.15	50
50	.03	10



Selects analyzer upper frequency range and resolution bandwidth. The BANDWIDTH markings also denote the lowest useful frequency of each range. For each range position, a low-pass filter with cutoff at 1.1 times the UPPER LIMIT is inserted in the signal path, and the sampling rate (three times UPPER LIMIT frequency) is automatically selected.

1.2.3 MEMORY Mode/TRANSIENT CAPTURE



1.2.3.1 MEMORY Mode Control/Indicators

Pressed to select one of the following memory modes of operation. Push button lights when mode is activated.

HOLD (S11) (D11)
When activated, the contents of the memory at that time is held and continuously outputted, no new data is accepted.

UPDATE (S10) (D10)
Input signal data is sampled and applied to the memory. The data is sampled at a rate consistent with the selected frequency range.

TRANSIENT CAPTURE (S9) (D9)
When pressed, the analyzer goes into MEMORY UPDATE mode (UPDATE indicator off) awaiting a transient capture trigger (EXT or INT). When triggered, the selected number of samples are loaded (UPDATE indicator lighted). Analyzer then goes into HOLD mode (HOLD indicator lighted).

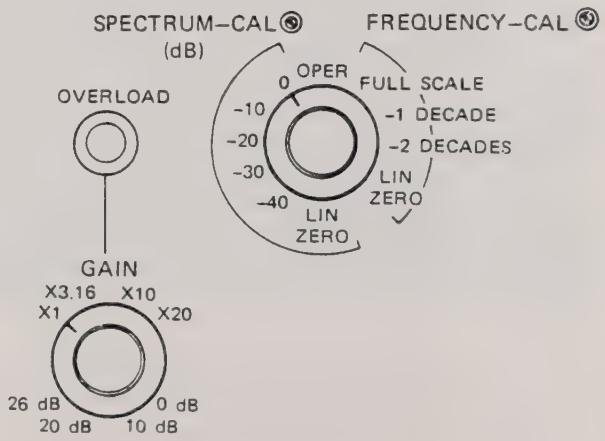
1.2.3.2 TRANSIENT TRIGGER Control (S6)

TRANSIENT TRIGGER control is used in Transient Capture mode to select INT (internal) or EXT (external) trigger. When set to INT, loading of the selected number of samples is initiated as a function of the input signal level. In EXT position, loading is initiated by application of a signal at TRIG INPUT connector J9 on the rear chassis.

1.2.3.3 TRIGGER LEVEL Control (R38–Main Frame)

TRIGGER LEVEL control (effective in both EXT and INT modes) provides 30 dB (–5 to –35 dB) attenuation of the selected trigger signal source, EXT or INT. For normal operation in EXT mode, the TRIGGER LEVEL control is set to –5 (extreme clockwise position) and a 1V 2-microsecond pulse is applied at J9. Trigger level responds to both positive- and negative-going signals.

1.2.4 Output Operate Mode Group



1.2.4.1 OPERATE/CALIBRATE Control (S3)

This control is referenced in this manual as the OPER/CAL control.

OPERATE
The spectrum of the applied signal is available at the output connectors in log and linear form, as selected,

for display on an oscilloscope or recorder. This output is in accordance with the selected mode, range, markers, etc.

SPECTRUM-CAL
In 0 dB position, an internally generated calibration signal equal in amplitude to the selected coarse input range is applied to the analyzer input circuit, thus providing a calibrated output spectrum.

The -10, -20, -30, and -40 dB positions provide accurately attenuated calibration levels referenced to the selected coarse input range. In LIN ZERO position, zero signal input is applied to provide a zero output reference point referenced to the selected coarse input range for overall spectrum amplitude axis calibration. In RTA FAST and SLOW modes, the spectrum of the CAL signal is continuously analyzed for display. In all other modes, the display is stopped at the fundamental of the CAL signal.

FREQUENCY-CAL
In FULL SCALE position, a d-c output proportional to full-scale of the ANALYSIS RANGE is provided in both log and linear form. The -1 DECADE and -2 DECADES positions provide 1/10 and 1/100 of full-scale output referenced to FULL SCALE position. LIN ZERO provides a zero reference point referenced to full-scale for overall frequency-axis calibration.

1.2.4.2 OVERLOAD Indicator (DS3)

Lights to indicate that the signal output range is being exceeded (the linear output exceeds 5V). Note that although the INPUT OVERLOAD indicator may not be lighted for a particular input signal, the output spectrum peak could exceed 5V linear dc, lighting the OUTPUT OVERLOAD indicator. Therefore the INPUT RANGE would need to be attenuated.

1.2.4.3 GAIN Control (S15)

Provides additional post-filter gain; X1 (unity or 0 dB), X3.16 (+10 dB), X10 (+20 dB) or X20 (+26 dB). Normally set to X1 for all periodic input signals. Additional gain can be inserted as required for a suitable output presentation when analyzing broadband signals such as white noise. Note that the frequency markers are attenuated in the X10 and X20 positions to prevent overloading.

1.2.4.4 Frequency Offset Control (R37 – Front-Panel)

This screwdriver-adjust control, located just to the right of the words "FREQUENCY-CAL," is used as follows:

When using display oscilloscope, select 10 intensity markers with SINGLE RESET control CURSOR INTENSIFY and internal FREQUENCY MARKERS; then adjust Frequency Offset Control so intensity markers coincide with peaks of frequency marker.

When using an X-Y recorder, select 0 db SPECTRUM-CAL output mode (input range fine attenuator control to 0 dB and FREQUENCY MARKERS-OFF) and adjust Frequency Offset control for maximum SPECTRUM signal output.

1.2.4.5 Zero dB Offset Control (R49 – Front-Panel)

This screwdriver-adjust control is located just to the right of the words "SPECTRUM-CAL" and is used when the Cursor is in the dB and INTENSIFY modes. To use, set the OPER/CAL control to 0 dB, set the Input Range fine attenuator to 0 dB and place the intensity marker at the peak of the fundamental of the calibration waveform. Then adjust the Zero dB Offset control for a Cursor display of 00.0 dB.

NOTE: A ±12 dB offset range is provided so the Zero dB reference may be set anywhere within this range as desired.

1.2.5 Output Mode Control Group

1.2.5.1 SEPARATION (R50 – Front-Panel)

Used in the chopped display modes (RTA/AVG, RTA/STORED, AVG/STORED), to add an offset voltage to the second listed signal. This signal can then be displaced upward for a dual display of the two listed signals.

1.2.5.2 Sweep Initiation Control (S5)

This control is used with the RTA FAST, the RTA SLOW, and the PLOTTER modes.

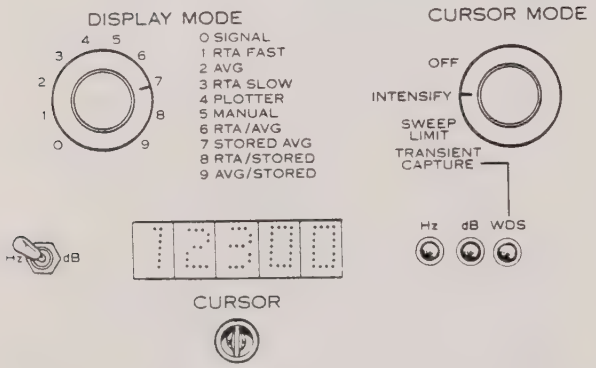
AUTO
The swept spectrum is continuously provided at selected mode and sweep rate.

MEMORY PERIOD (S5)
A swept spectrum output is provided only once each time the memory is completely loaded with new data, thus redundant spectrum outputs are eliminated. (Note: In MEMORY HOLD mode, no new data is entered so the spectrum is not swept.)

SINGLE RESET Control/Indicator (S12) (DS12)
Used in SINGLE RESET mode and for Cursor zero. If the analyzer is reset, pressing the control will initiate a single sweep. If the analyzer is sweeping, pressing the control will reset the sweep. The Cursor is set to cell zero when the control is pressed. Indicator is lighted when the analyzer is not reset. The SWEEP TRIG input at rear chassis connector J20 accepts a 5V, 2 μs pulse to perform the function described above.

When in the PLOTTER mode, a plot is started from the reset condition by pressing the SINGLE RESET control once; if pressed again during the sweep, the plotter will reset to the lower sweep limit and remain there until another sweep is initiated. When the sweep is completed, the pen will stop at full scale. The SINGLE RESET control must be pushed to reset the sweep.

1.2.5.3 DISPLAY MODE Control (S4)



This control selects the time base of the spectrum output display and the signal to be displayed.

0 SIGNAL
The amplified RTA input is routed to the SPECTRUM LIN output connector J2, on the rear of the chassis. The FREQUENCY LIN output connector J17, becomes a sawtooth sweep which is triggered by the RTA input signal and is timed to present ten cycles of a full scale sinusoid.

1 RTA FAST (0.05 sec)
Output spectrum display is presented 20 times a second regardless of the frequency range selected. Note that on low frequency ranges many displays of the same spectrum may be outputted before the memory is completely updated.

2 AVG
Output spectrum is derived from an external averager. Output spectrum display is presented 20 times a second regardless of the frequency range selected.

3 RTA SLOW (0.1 sec)
Output spectrum display is presented 10 times a second, thus taking 100 ms to complete each display. At this rate 1000 filter locations are synthesized, which allows a smoother coverage of the spectrum.

4 PLOTTER
Assuming no input signal, the basic output spectrum sweep times of 32, 64, or 320 seconds are available by connection of an internal jumper. In the PLOTTER mode a sweep rate feedback circuit is activated.

With a single input, the time for a complete sweep becomes a function of the change of signal amplitude. That is, the sweep is automatically slowed when a large amplitude variation occurs in the Y-axis.

5 MANUAL
Analyzer operates as a tuned filter with the filter center frequency determined by the Cursor location. Refer to the Cursor control description.

6 RTA/AVG
Output spectrum display is chopped between the RTA output and the Averager output; i.e., each output is divided by two and separated by the SEPARATION control. This chopped output is presented twenty times a second regardless of the frequency range selected.

7 STORED AVG
The output from an external stored average module (Memory) is routed from the rear chassis connectors to the output spectrum display. Output spectrum display is presented 20 times a second regardless of frequency range selected.

8 RTA/STORED
The output spectrum display is chopped between the RTA output and the Stored Average output from the external Memory which is routed from the rear chassis connectors. The chopped display is presented 20 times a second regardless of frequency range selected.

9 AVG/STORED
Output spectrum display is chopped between the Averager output and the output from the Memory. The chopped display is presented 20 times per second regardless of the frequency range selected.

1.2.5.4 CURSOR MODE (S16)

In this manual the designation CURSOR is used as follows:

- CURSOR – Front panel control which steps the cell location.
- Cursor – The cell contents displayed in the LED display.
- cursor – The function performed by the CURSOR MODE and the CURSOR group of controls.
- CURSOR MODE – Front panel control which selects Cursor subfunction.

Provides additional subfunctions as marked. For any of the following functions using the Cursor, a position marker is provided at the rear chassis connector J25. This marker indicates when the cell location is reached.

INTENSIFY
Used in all modes except MANUAL and PLOTTER to provide an intensity marker on the X-Y display oscilloscope. Position of the marker is determined by Cursor address except for address 000 which provides 10 equally spaced markers. Cursor is set to address 000 by pushing the SINGLE RESET button.

SWEEP LIMIT
Sweep will be truncated at a point selected by the Cursor address. Cursor will read out the frequency of the truncation point. Amplitude reading will be invalid.

TRANSIENT CAPTURE
The number of digital words (samples) to be loaded into memory during TRANSIENT CAPTURE mode is determined by the Cursor (250–999 words). If the CURSOR MODE control is not set to TRANSIENT CAPTURE, the TRANSIENT CAPTURE mode loads 1500 data points.

OFF
The control should be set to the OFF position when none of the functions are desired.

1.2.5.5 CURSOR Group

The front panel controls labeled CURSOR and Hz/dB and the front panel LED displays are associated with the CURSOR MODE of operation.

CURSOR Control (S18)
Provides a means of examining a particular frequency cell when the CURSOR MODE control is in the INTENSIFY Mode. Pressing and holding the CURSOR control in either direction moves the intensity dot in that direction at a fixed rate. Pressing the control in either direction for less than 1/2 second and then releasing it, will move the intensity dot one cell in the same direction in which the control is pressed.

Hz/dB Control (S17)
The Hz/dB Control determines the Cursor readout units except when the CURSOR MODE is set to TRANSIENT CAPTURE. The readout is then given in number of digital words in memory (WDS).

Cursor Readout
The Cursor readout is a 5-digit LED display which can present the selected cell frequency in hertz, the selected cell amplitude in dB, or the number of digital words to be stored in memory. A minus is displayed for –dB; +dB displays a blank in that position. At times, a decimal point is displayed according to the information being displayed.

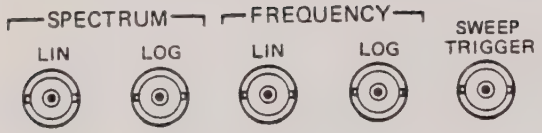
Unit Indicator
Three LED indicators located to the right of the Cursor readout are labeled Hz, dB, and WDS to give a visual indication of the unit of the readout display at the time.

Hz (DS16) – Lighted when Cursor Readout is in hertz.

dB (DS15) – Lighted when Cursor Readout is in dB.

WDS (DS14) – Lighted when Cursor Readout is in words.

1.2.6 Outputs



LIN SPECTRUM (J57)

Provides 0V to 5V d-c output. This is a smoothed version of the SPECTRUM LIN STEP output that is available at J1 on the rear chassis. Connected in parallel to J2 on the rear chassis.

LOG SPECTRUM (J58)

Provides 0V to 1V d-c output proportional to the log of the LIN output described above. Connected in parallel to J3 on the rear chassis.

LIN FREQUENCY (J52)

Provides 0V to 5V d-c output. This is a smoothed version of the FREQUENCY LIN STEP output that is available at J16 on the rear chassis. Connected in parallel to J17 on the rear chassis.

LOG FREQUENCY (J53)

Provides 0V to 1V d-c output proportional to the log of the LIN output described above. Connected in parallel with J18 on the rear chassis.

SWEEP TRIGGER (J54)

Provides a transition from 5V to 0V that is synchronized with the start of each sweep; transition is back to 5V at end of sweep. Connected in parallel with SWEEP TRIG connector J20 on the rear chassis.

1.2.7 LOCAL/REMOTE Control (S19)

Provides a means of remote selection of certain front-panel functions and remote sensing of certain front-panel parameters by an auxiliary computer.

LOCAL

Operation of the RTA is unchanged, except that the following parameters are sensed remotely by the computer via multipin connector J30.

ANALYSIS RANGE
INPUT RANGE
  Coarse Attenuator
  Fine Attenuator
GAIN
OVERLOAD
  INPUT
  OUTPUT
  IN-BAND
  OUT-OF-BAND

CAUTION The Cursor address lines are not disconnected from the remote lines by the LOCAL/REMOTE control. If it is necessary for the computer to operate totally independent of the analyzer when the Cursor Position is set on something other than 000, it will then be necessary to remove control lines or electrically disconnect them by the appropriate use of diodes external to the RTA.

REMOTE

Operation of the RTA is altered in the following manner:

Remote selection of the following functions:
  INPUT RANGE, both Coarse (10 dB) and Fine (1 dB) attenuators
  ANALYSIS RANGE, all 10 frequency ranges from 10 Hz to 50 kHz
  GAIN (Post Filter) at 0, 10, 20 or 26 dB
  MANUAL MODE

Remote sensing of the following parameters:
  INPUT RANGE, both Coarse (10 dB) and Fine (1 dB)
  ANALYSIS RANGE
  GAIN (Post Filter)
  OVERLOAD (input, output and out-of-band)

*Remote selection of following X-axis sweep parameters
  Filter location
  Sweep rate
  Sweep start point
  Sweep stop point

1.2.8 POWER Control/Indicator

POWER Control/Indicator (S13) (DS13)

Press to turn instrument power on or off; lighted when unit is powered.

*DISPLAY MODE Control must be set to MANUAL (position 5). Cursor address must be set to 000.

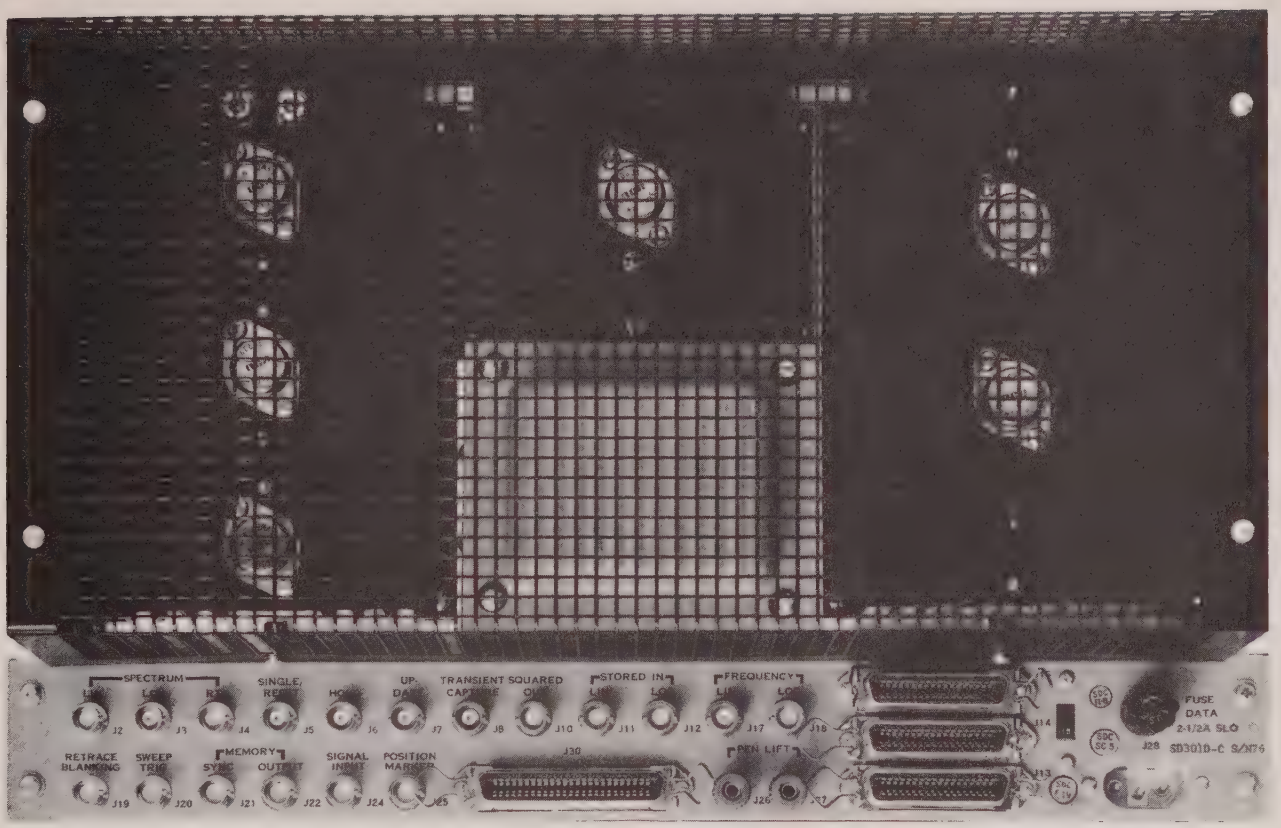


Figure 1-3. Rear Chassis

1.3 REAR CHASSIS FUNCTIONAL DESCRIPTION (See Figure 1-3.)

This section gives the functional description of rear chassis connectors.

LIN SPECTRUM (J2)

Provides 0V to 5V d-c output. Connected in parallel with front-panel SPECTRUM LIN output connector, J57.

LOG SPECTRUM (J3)

Provides 0V to 1V d-c output proportional to the log of LIN output. Connected in parallel with front-panel SPECTRUM LOG output connector, J58.

RTA SPECTRUM (J4)

Normally provides RTA SPECTRUM LOG output (as described for J3). Jumper on circuit card A26 can be changed to provide LIN STEP or LIN output (as described for J2). This output is not affected when using External Averager.

SINGLE RESET (J5)

Used only in SINGLE RESET mode. Accepts external sweep trigger signal, nominally 5V at 2-microsecond duration. Application of pulse performs same action as pressing the front-panel SINGLE RESET control.

HOLD (J6)

Application of a nominal 5V, 2-microsecond pulse to this input will automatically place the analyzer in the corresponding mode of operation.

UPDATE (J7)

Application of a nominal 5V, 2-microsecond pulse to this input will automatically place the analyzer in the corresponding mode of operation.

TRANSIENT CAPTURE (J8)

Application of a nominal 5V, 2-microsecond pulse to this input will automatically place the analyzer in the corresponding mode of operation.

SQUARED OUTPUT (J10)

Provides the squared value of the spectrum magnitude. Requires use of Output Amplifier Assembly No. 11430-3 (optional) or 10099801 (optional).

STORED IN LIN (J11)

This 0V to 5V d-c input will be selected for display in any of the STORED modes. Input is derived from the external Memory unit.

STORED IN LOG (J12)

This 0V to 1V d-c input will be selected for display in any of the STORED modes. Input is derived from the external Memory unit.

J13

Auxiliary functions connector for interconnecting RTA to an SDC Ensemble Averager. Refer to Table 2-6 in Section II for pin functions for SDC Ensemble Averager.

J14

Auxiliary functions connector for interconnecting RTA to an SDC Signature Ratio® Adapter. Refer to Table 2-7 in Section II for pin functions for SDC Signature Ratio® Adapter.

J15

Auxiliary functions connector for interconnecting RTA to an SDC Spectrum Translator. Refer to Table 2-8 in Section II for pin functions for SDC Spectrum Translator.

LIN FREQUENCY (J17)

Provides 0V to 5V d-c output. Connected in parallel with front-panel FREQUENCY LIN output connector, J52.

LOG FREQUENCY (J18)

Provides 0V to 1V d-c output proportional to the log of LIN OUTPUT. Connected in parallel with front-panel FREQUENCY LOG output connector, J53.

RETRACE BLANKING (J19)

Provides 0V during sweep, and 5V d-c level from end of sweep to beginning of the next sweep.

SWEEP TRIG (J20)

Provides a transition from 5V to 0V that is synchronized with the start of each sweep; transition is back to 5V at end of sweep. Connected in parallel with SWEEP TRIGGER connector, J54, on the front panel.

MEMORY SYNC (J21)

Provides a 5V, approximately 2-microsecond pulse every time the memory recirculates.

MEMORY OUTPUT (J22)

Provides a speeded-up replica of the input signal that is stored in memory. This signal also contains the internal markers, if selected.

SIGNAL INPUT (J24)

Accepts signal to be analyzed; is connected in parallel with front-panel SIGNAL INPUT connector; is affected by setting of AC/DC control. Refer to front-panel description for SIGNAL INPUT connector, AC/DC control. Connected in parallel with SIGNAL INPUT connectors, J45, and J38 internally.

POSITION MARKER (J25)

Provides a Cursor position marker approximately +4V; duration varies according to mode selected. For example, in RTA FAST mode with CURSOR MODE set to OFF, position marker is approximately 100 microseconds duration; with CURSOR MODE set to INTENSIFY, approximately 500 microseconds duration. In PLOTTER mode, position marker stays high for time allotted to displaying the particular filter location.

PEN LIFT (J26, J27)

Provides a normally open set of contacts. During a plotter sweep the contacts are closed and are then automatically opened at end of sweep. Circuit is isolated from ground. Before using, observe CAUTION of Paragraph 2.3.3 in Section II of this manual.

AUXILIARY FUNCTIONS (J30)

Auxiliary functions connector for interconnecting the RTA to a computer. Refer to Table 2-9 in Section II for pin functions for this connector.

115/230 Switch

Facilitates changeover of primary power input circuit for either 115V or 230V operation. Proper input voltage to be applied shows in window; screwdriver blade slot is up for 115V operation and down for 230V operation.

FUSE

Contains 3AG type, 2-1/2A, SLO-BLO fuse.

POWER IN (J28)

Accepts 3-wire plug and cable (supplied) for applying 115/230 Vac 50–60 Hz primary input power. Center terminal is chassis ground.

1.4 SPECIFICATIONS

Upper Freq Limit (Hz)	3 dB Filter Bandwidth (Hz)	Memory Period (sec)	Resolution (Hz)
50,000	150	0.01	100
20,000	60	0.025	40
10,000	30	0.05	20
5,000	15	0.1	10
2,000	6	0.25	4
1,000	3	0.5	2
500	1.5	1.0	1
100	0.3	5.0	0.20
50	0.15	10.0	0.10
10	0.03	50.0	0.02

Sensitivity (for full scale output)
0.1 Vrms to 28.2 Vrms, adjustable in 1 dB steps

Level Indication
Five digitally driven indicator lamps provide correct indication input level regardless of waveform.

Impedance
100k ohm

Coupling
Selectable DC/AC (0.4 Hz Lower 3 dB point)

DYNAMIC RANGE
(full scale to minimum 54 dB discernible signal)

NOISE LEVEL
Average level 60 dB down from full scale with zero input signal

FREQUENCY MARKERS
10 equally spaced markers – or external input

MODES OF OPERATION
May be selected manually or remotely triggered

Update
Memory continuously updates with new data input

Hold
Last data in memory is continuously recycled – no new information is added.

Transient Capture
With CURSOR MODE set to TRANSIENT CAPTURE, CURSOR locator setting determines number of words (data points) to be loaded into memory; otherwise, 1500 words are loaded. Triggering of transient capture mode (start of load cycle) may be done either externally with a pulse input or from the data itself. The d-c coupled triggering level is adjustable (for internal or external operation) from –5 dB to –35 dB. The memory is loaded, then HOLD mode is automatically selected.

EXTERNAL CONTROL OF OPERATIONAL MODE
Application of an external d-c level shift (nominally 5V, 2 μs minimum duration) to either the Update, Hold or Transient Capture input will automatically cause the selected mode to be activated.

INTERNAL CALIBRATION
Calibrates entire analyzer from signal input to d-c outputs.

(Y) Spectrum Axis
LIN – Full scale and zero

LOG – Full scale, –10 dB, –20 dB, –30 dB, –40 dB

(X) Frequency Axis
LIN – Full scale and zero

LOG – Full scale, –1 decade, –2 decades

DISPLAY MODES

Sweep Speed
RTA FAST – a new sweep is initiated every 50 ms giving a "flicker free" oscilloscope display in AUTO mode.

RTA SLOW – a new sweep is initiated every 0.1s by stepping the synthesized filter in 1/2 normal steps.

PLOTTER – a plot is completed in 32, 64, or 320 seconds as determined by an internal jumper; automatically controlled by SRF.

MANUAL – sweep position is controlled by CURSOR locator.

External Averager – displayed sweep rate is placed under control of Averager, either RTA FAST, EXT, or PLOTTER as selected on the Averager.

All other modes are same as External Averager mode.

Sweep Initiation

AUTOMATIC – spectra are presented repeatedly, one after another.

SINGLE RESET – a complete spectrum is presented each time a trigger pulse is provided or each time the sweep trigger control is depressed.

MEMORY PERIOD – a sweep is initiated each time a memory load cycle is completed. Each spectrum display is statistically independent of the previous display and redundant spectra are eliminated.

Cursor Mode

Provides subfunctions of RTA FAST, RTA SLOW, and PLOTTER modes; provides intensity markers, sweep limit, and transient capture, all controlled by CURSOR control.

Position Marker

Provides a marker pulse output independently controlled by CURSOR control.

OUTPUTS

Spectrum Axis

Lin step – 0 to 5V detector output

Lin – 0 to 5V (nominal) smoothed output of detector

Log – 1V log smoothed output of detector

Frequency Axis

Lin step – 0 to 5V stepped ramp

Lin – 0 to 5V (nominal) smooth ramp

Log – 1V smooth log ramp

Sweep Trigger – provides a transition from 5V to 0V that is synchronized with start of each sweep; transition is back to 5V at end of sweep.

Retrace Blanking – provides 0V during sweep, and 5V d-c level from end of sweep to beginning of next sweep

MEMORY CONTENTS

500 mV p-p full scale signal displaying the analog replica of the speeded up signal stored in memory

FREQUENCY RESPONSE

±0.5 dB at filter center frequency
±1 dB off of filter center frequency

LINEARITY OF SPECTRUM OUTPUT

±1/4% of full scale or ±1/2 dB, whichever is greater

SEPARATION

Two equal amplitude sinusoids, spaced 2 filter bandwidths apart, when applied simultaneously to the RTA will exhibit an average 6 dB valley between the spectral peaks.

SELECTIVITY

Filter response is at least –25 dB at a frequency removed from center frequency by 2 bandwidths ±15% and –40 dB at 3.5 bandwidths ±15% (BW = 3% of FS)

FREQUENCY LINEARITY

±0.2% of best straight line of full analysis range; offset is adjustable with built-in test feature so best straight line matches calibration points.

POWER

105–125/210–250 Vac (switch selectable);
50 to 60 Hz; ≈175W

DIMENSIONS

Height	26,6 cm (10-1/2")
Width	48,3 cm (19")
Depth	53,3 cm (21")
Shipping Weight	27,2 kg (60 lb)

SECTION II
OPERATION

2.1 GENERAL

To aid the operator in using the Real Time Analyzer (RTA), the instructions and procedures in this OPERATION section discuss initial setup and operation of the RTA in conjunction with an oscilloscope and X-Y recorder. At the end of this section is a table of peripheral instruments that will interface and further enhance the capability of the RTA. Please refer to the specific manual for detailed operation instructions of peripheral instruments.

The operator should read and understand Sections I and III of this manual before operation of the RTA.

2.2 INITIAL SETUP FOR THE RTA

The steps outlined in the following will initialize the RTA so that the basic electronics of the RTA are fully operational and the operator will be ready to connect and calibrate the output display devices. After performing the powering procedure which follows, proceed to the steps in the Legend – RTA INITIAL SETUP, which are grouped according to their functions and are keyed with numbers to the applicable front-panel controls.

- Check that the 115/230 slide switch on the rear of the chassis of the RTA is properly installed for the available input line voltage and a fuse with the proper rating is installed.

- Connect the power cord to the primary power source.

- Press the POWER control/indicator on the front panel; it should light to indicate that the unit is powered.

2.3 DISPLAYING AND RECORDING RTA OUTPUT

A visual display and a hardcopy of the RTA signal spectrum analysis is obtained by connecting the RTA to an oscilloscope and an X-Y recorder. Setup instructions for interconnecting the RTA with these display devices are given in Paragraphs 2.3.1, 2.3.2, and 2.3.3. Interconnect diagrams for specific model numbers are found at the end of this section.

2.3.1 Oscilloscope Setup

The oscilloscope to be used must be d-c coupled and have a bandwidth of 100 kHz or more; the sensitivity must be 100 mV/cm or better. The following procedures assume an oscilloscope graticule that is linearly incremented; 10 horizontal and 8 or more vertical divisions. Figure 2-1 gives the setup for the RTA and the oscilloscope. Interconnection diagrams are given for specific models at the end of this section.

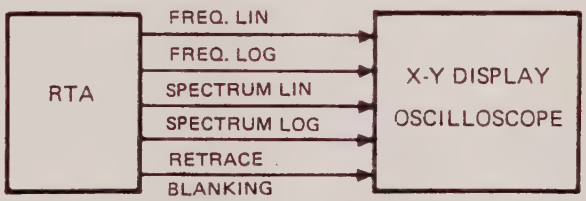


Figure 2-1. RTA and X–Y Display Oscilloscope Setup

Connect the X-Y display oscilloscope and the RTA, apply power and setup according to the Legend, Figure 2-2. The oscilloscope should display, uncalibrated, 10 frequency markers with an intensity dot superimposed on the peak of each marker. All intensity dots may not be located exactly on the peak of each marker; if not, do not attempt to correct this condition at this time. The Legend, Key 2 of Figure 2-3 gives a procedure to calibrate the marker display.

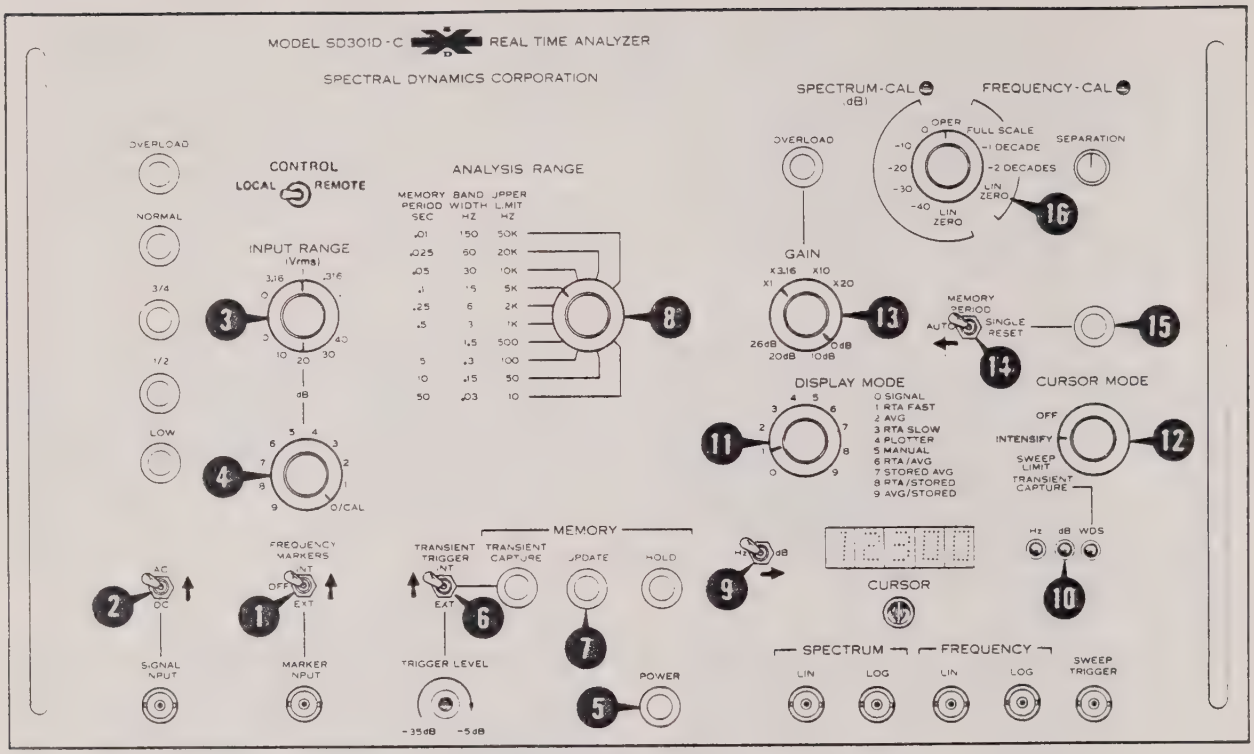


Figure 2-2. Initializing the Analyzer

LEGEND – RTA Initial Setup

FUNCTION	KEY	FRONT-PANEL CONTROL/INDICATOR	POSITION
INPUT	(1)	FREQUENCY MARKERS	INT
	(2)	AC/DC	AC
	(3)	INPUT RANGE Coarse Attenuator	1 Vrms
	(4)	INPUT RANGE Fine Attenuator	0/CAL
ANALYSIS	(5)	POWER (Press to light)	LIGHTED
	(6)	TRANSIENT TRIGGER	INT
	(7)	ANALYSIS RANGE	5 kHz
	(8)	MEMORY (Press to light)	UPDATE lighted
OUTPUT/DISPLAY	(9)	Hz/dB	dB
	(10)	dB LED	LIGHTED
	(11)	DISPLAY MODE	RTA FAST (1)
	(12)	CURSOR MODE	INTENSIFY
	(13)	GAIN (Overload indicator extinguished)	X1
	(14)	Sweep Initiation	AUTO
	(15)	SINGLE RESET (Press to reset intensity dots)	LIGHTED
	(16)	OPER/CAL	OPER

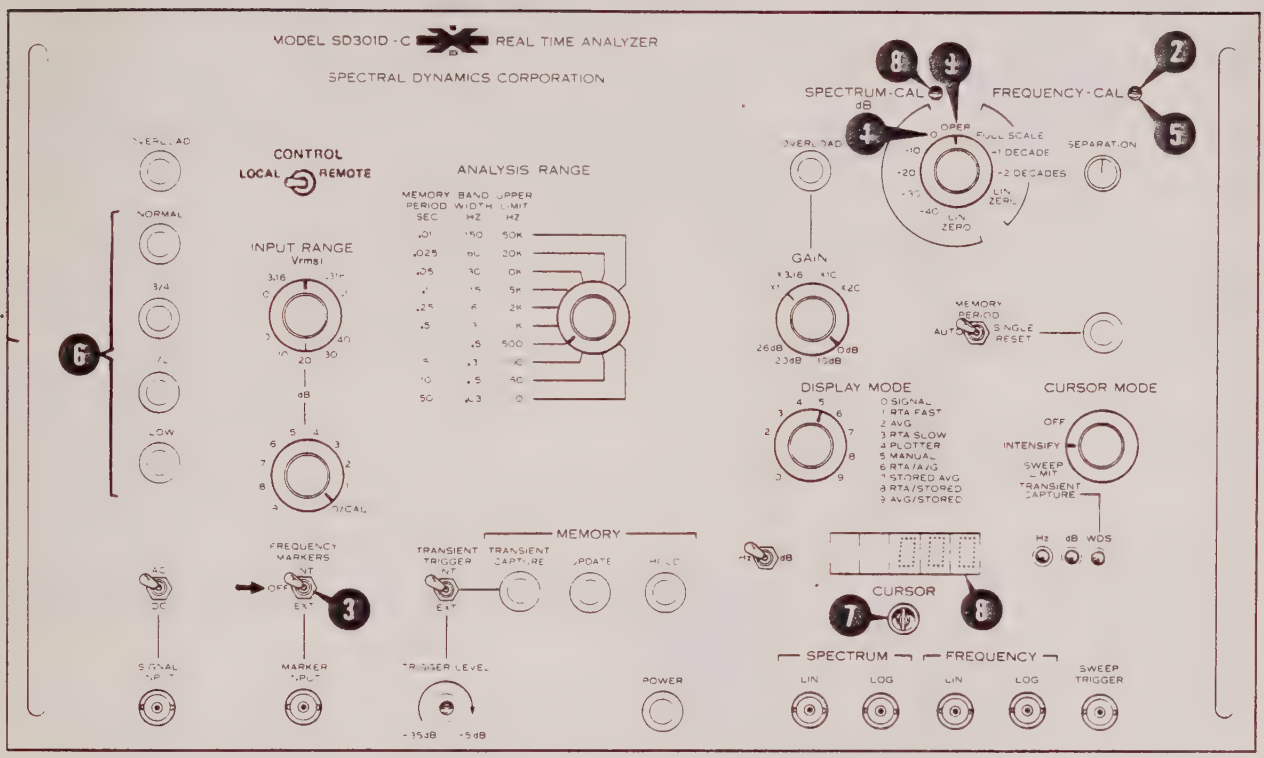


Figure 2-3. RTA Setup for Calibration of X-Y Display Oscilloscope

LEGEND – RTA Setup for Calibration of X-Y Display Oscilloscope

X-Axis Display Calibration

① Initialize the RTA per Legend, Figure 2-2. On the X-Y Display Oscilloscope use the X-Axis Zero Offset and Gain controls to set FREQUENCY MARKERS to coincide with oscilloscope vertical graticule lines.

② Adjust FREQUENCY-CAL pot until all intensity dots are resting on top of Marker peaks. The oscilloscope display should be the same as shown in Figure 2-4.

③ Turn FREQUENCY MARKERS control to OFF.

Y-Axis Display Calibration

④ Turn OPER/CAL control to the 0 dB position. The oscilloscope display should be the same as shown in Figure 2-5. For LOG amplitude presentation, adjust the oscilloscope Y-Axis Gain and Offset Controls so a 10 dB voltage change on the SPECTRUM-CAL control covers one graticule division on the display oscilloscope.

⑤ Adjust the FREQUENCY-CAL pot for maximum peaking of the calibration signal.

⑥ The LOW, 1/2, 3/4 and NORMAL lights will be on when the OPER/CAL Control is in the 0 dB position. The OVERLOAD light will be extinguished.

⑦ Using the CURSOR Control, place the intensity dot at the peak of the CAL signal fundamental.

⑧ Adjust the Zero dB Offset control (pot) until the Cursor LED readout indicates 00.0 dB. The LED amplitude readout is now normalized to the full scale CAL signal on any selected INPUT RANGE.

⑨ Turn the OPER/CAL control to OPER.

The oscilloscope is now calibrated for SPECTRUM LOG amplitude and LINEAR FREQUENCY display.

2.3.2 Display Oscilloscope Calibration

2.3.2.1 Calibration Procedure for Display Oscilloscope

To calibrate the amplitude and frequency axis of the oscilloscope, follow the Legend steps that are keyed by number to the applicable front-panel RTA controls shown in Figure 2-3. Before beginning the calibration, connect the RTA and the oscilloscope according to Figure 2-1 and the interconnection diagram at the end of this section.

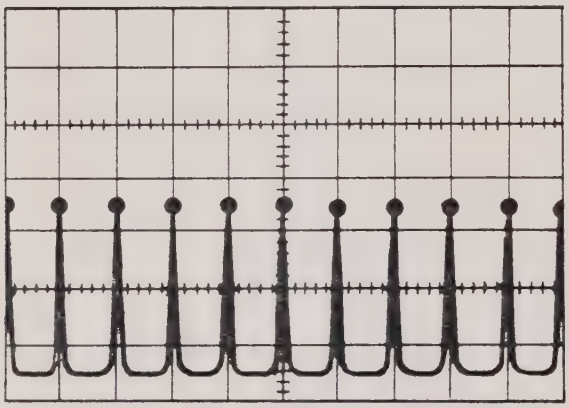


Figure 2-4. Frequency Markers with 10 Intensity Markers

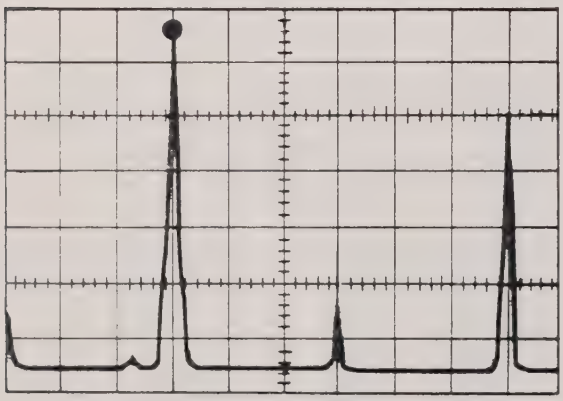


Figure 2-5. Calibration Signal Log Display

2.3.2.2 Viewing the Signal Time History

The amplified RTA input is routed to the SPECTRUM LIN output connector J2, on the rear of the chassis. The FREQUENCY LIN output connector J17, becomes a sawtooth sweep which is triggered by the RTA input signal and is timed to present ten cycles of a full-scale sinusoid. Table 2-1 presents the corresponding time base for each Analysis Range.

Table 2-1. Signal Time-Base Scale Factors

RTA Analysis Range	Corresponding Time Base* for Viewing Signal Input
50 kHz	0.02 ms/division
20 kHz	0.05 ms/division
10 kHz	0.1 ms/division
5 kHz	0.2 ms/division
2 kHz	0.1 ms/division
1 kHz	1 ms/division
500 Hz	2 ms/division
100 Hz	10 ms/division
50 Hz	20 ms/division
10 Hz	100 ms/division

*The time-base presented assumes an X-Y display oscilloscope which has the X-axis graticule divided into 10 equal increments.

2.3.3 X-Y Recorder Calibration

The procedure for calibrating an X-Y recorder using the RTA internal amplitude and frequency calibration signals is given in the Legend of Figure 2-6. A typical setup for the RTA, an oscilloscope and an X-Y recorder is given in Figure 2-7. Interconnection diagrams for specific models are given at the end of this section.

NOTE: The desired -20 dB point on the graph can be determined as follows:

- If graph has logarithmic Y-axis, a -20 dB voltage change should be set to cover one decade. But, if plotting power spectral density (PSD) is desired, a 20 dB voltage change should be set to cover two decades of display.
- If graph has linear Y-axis, it may be desirable to calibrate so that each major division represents a 10 dB voltage change. (A 20 dB voltage change would therefore be set to cover two major divisions.)

The plot obtained should be a hard copy of the oscilloscope display shown in Figure 2-5. Figure 2-8, LOG Display of the RTA Internal Calibration Signal, is keyed to the X-Y Recorder Calibration procedure and represents the hardcopy of the oscilloscope display of the RTA signal analysis.

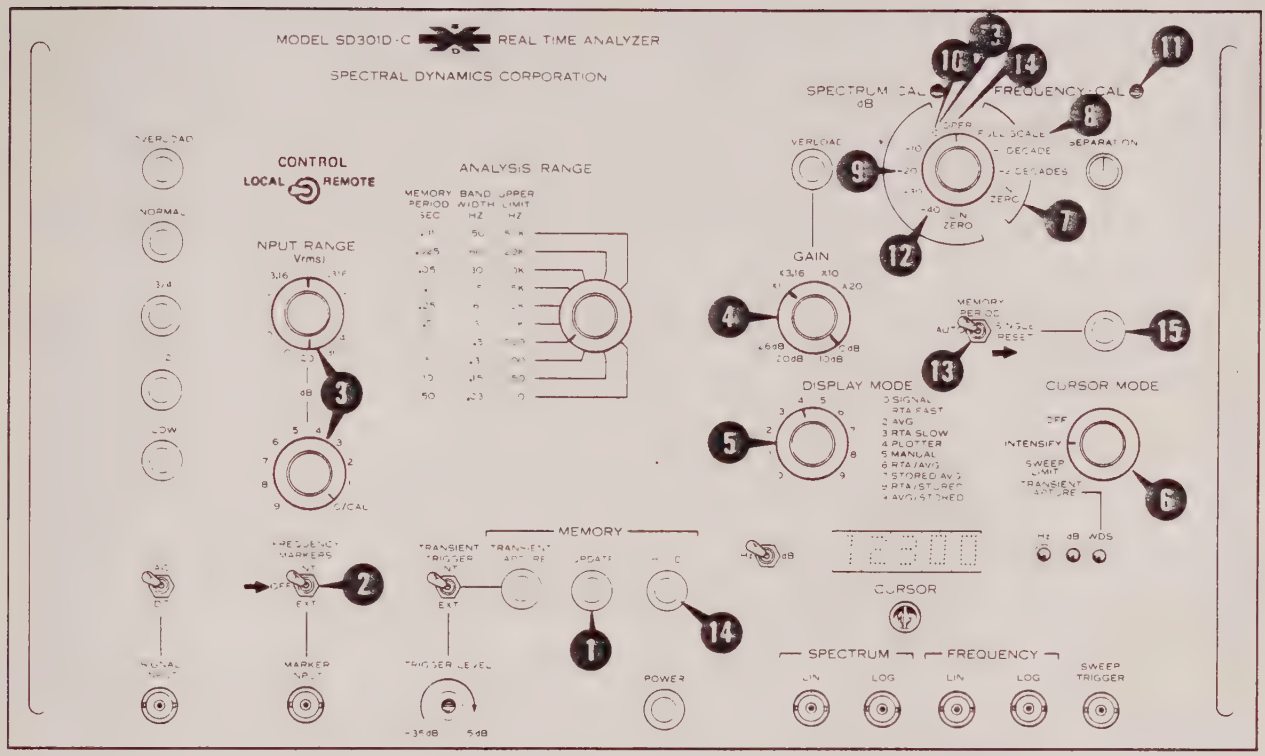


Figure 2-6. RTA Setup for X-Y Recorder Calibration

LEGEND — RTA Setup for X-Y Recorder Calibration

(1) Press UPDATE control/indicator; should light.

(2) Turn FREQUENCY MARKERS to OFF.

(3) Turn INPUT RANGE Coarse Attenuator to 1 Vrms; Fine Attenuator to 0/CAL.

(4) Turn GAIN control to X1.

(5) Turn DISPLAY MODE control to PLOTTER.

(6) Turn CURSOR MODE to INTENSIFY.

(7) Turn OPER/CAL control to FREQUENCY-CAL LIN ZERO. Energize the Plotter servo control and adjust the Plotter X-Axis Zero control.

(8) Turn OPER/CAL control to FREQUENCY-CAL FULL SCALE. Adjust the Plotter X-Axis Variation control to set pen for selected Upper Limit Analysis Range. Repeat Steps 7 and 8 until the plotter X-Axis is accurately adjusted.

(9) Turn OPER/CAL control to −20 dB. Adjust Plotter Y-Axis Zero control to set pen near −20 dB point on graph. Refer to Figure 2-8 and the note for selecting the −20 dB point.

(10) Turn OPER/CAL control to 0 dB. Adjust Plotter Y-Axis Variation control to set pen near 0 dB point for selected full scale INPUT RANGE.

(11) Adjust FREQUENCY-CAL potentiometer (FP-R37) for maximum peak on graph. Repeat Steps 9 and 10 until the Plotter Y-Axis is accurately adjusted.

(12) Turn OPER/CAL control to −40 dB for a check of linearity.

(13) Turn OPER/CAL control to 0 dB. Place Sweep Initiation control in the SINGLE RESET position.

(14) Simultaneously depress the MEMORY HOLD control and turn the OPER/CAL control to OPER.

(15) Press the SINGLE RESET control/indicator to start the plotter sweep. The plotter pen should drop automatically if the AUTO PEN LIFT control is connected to the plotter.

CAUTION To prevent permanent damage to the pen lift relay contacts in the RTA, be sure that a diode is installed across the pen lift solenoid coil in the recorder being used.

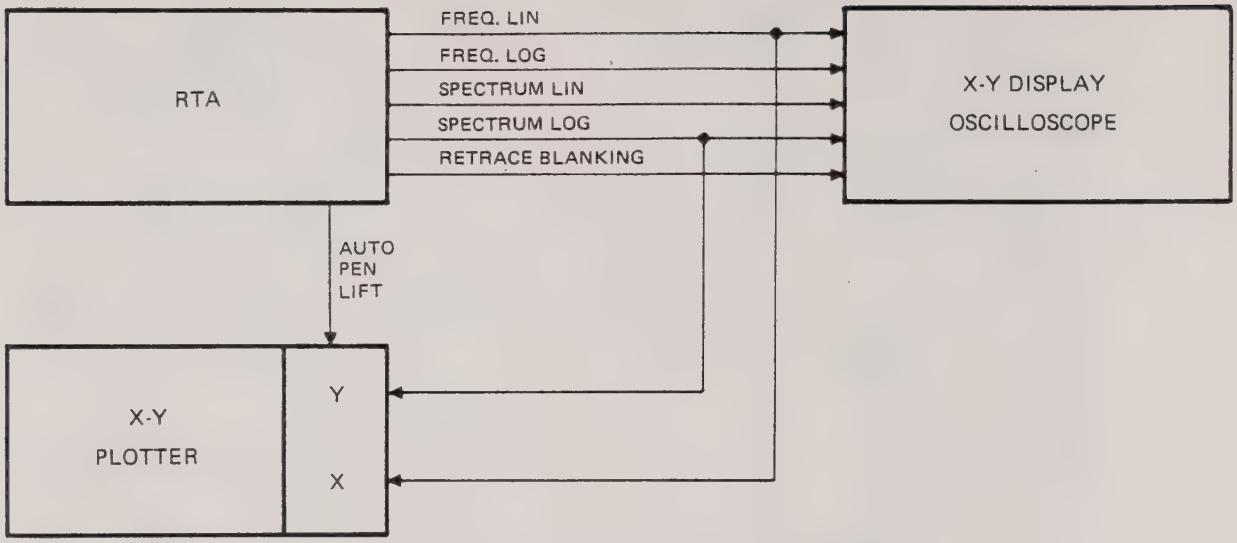


Figure 2-7. Setup for RTA, X-Y Recorder & Oscilloscope

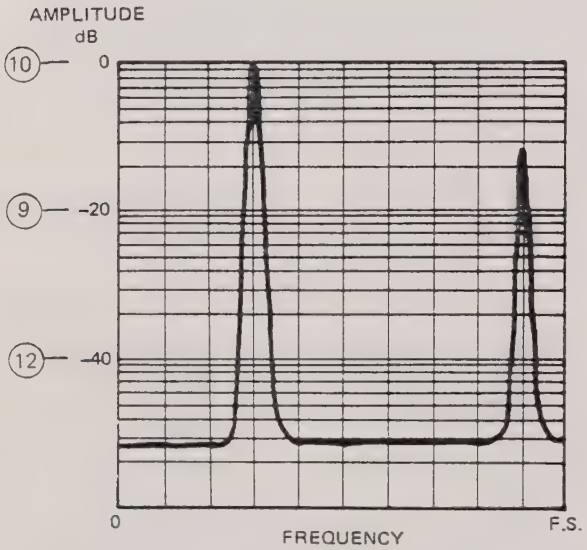


Figure 2-8. X-Y Recorder Display

2.4 GENERAL APPLICATIONS AND ASSOCIATED SETUP PROCEDURES

This section contains information and examples of typical applications of the RTA and Accessory Instruments. The basic objective of these examples is to provide the operator with interconnect and setup information that makes the instrumentation task easier and allows more time for solving problems. The following examples and procedures refer to transducers and amplifiers in a general sense without reference to specific types.

2.4.1 Analysis of a Periodic Signal

This procedure is intended to guide the operator through a typical operational program using an oscilloscope and an X-Y recorder. Assume for this example that a data signal is being generated from an accelerometer attached to a running test specimen or an external oscillator. The output of the accelerometer and conditioning amplifier have been normalized to an output sensitivity of 10 mV/g. Refer to Figure 2-9 for recommended setup.

a. Apply power to the RTA, the oscilloscope and the X-Y recorder.

b. Initialize the front panel controls on the RTA per the steps in the Legend of Figure 2-10.

c. Refer to the Legend of Figure 2-3, for recommended steps for calibration with an X-Y Display Oscilloscope.

d. Refer to Figure 2-6, steps 1 through 12, for calibration procedure with the X-Y Recorder Display. Set OPER/CAL control to OPER.

e. Apply the data signal to the RTA SIGNAL INPUT connector and adjust the INPUT RANGE controls for a normal level. Assume for this example that the INPUT RANGE Coarse attenuator is set to .316 Vrms and the Fine attenuator is set to 4 dB.

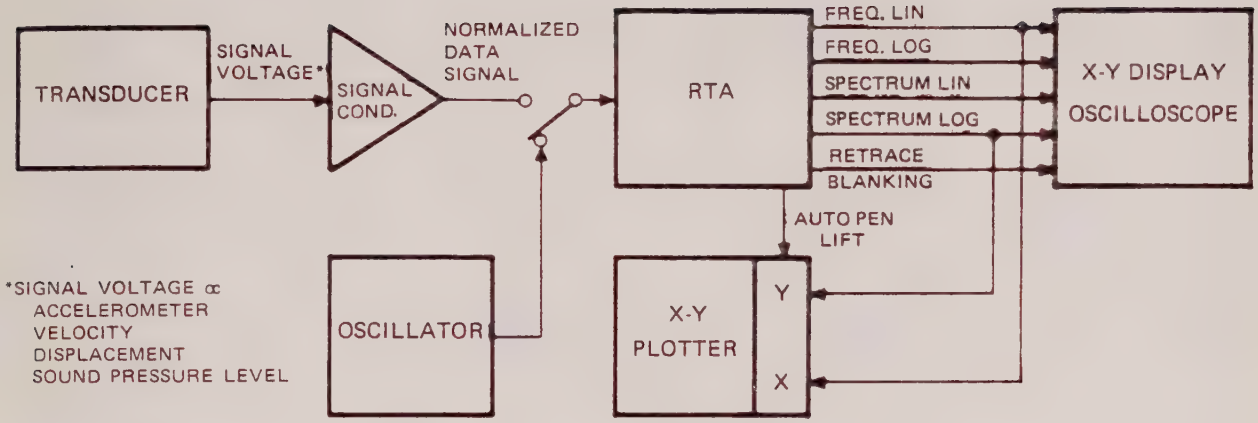


Figure 2-9. Setup for Periodic Signal Analysis

f. Set the OPER/CAL control to SPECTRUM-CAL 0 dB.

NOTE: The 0 dB calibration level is equivalent to an input level of 3.16g rms or 44.68g peak, based on a signal sensitivity of 10 Vrms/g rms. The FULL SCALE Signal level that the RTA can accommodate on the 31.6 Vrms range is 4 dB higher because the INPUT RANGE fine attenuator control is set at the 4 dB position for this example.

g. Adjust the oscilloscope zero position control so that the peak of the display is 4 dB down from FULL SCALE.

h. Set the DISPLAY MODE control to PLOTTER and energize the servos on the X-Y Recorder.

i. Calibrate the recorder Y-axis for a 0 dB indication of 31.6g rms (use the ZERO) control and position the pen over the 31.6g horizontal line); then place the recorder in standby mode.

CAUTION

Both the INPUT RANGE fine attenuator and post filter GAIN controls are in the calibration signal "path," and, therefore affect the output signal level. If they cannot be preset using the actual data signal, any change of settings required after calibration must be compensated for by a corresponding change in dB on the recorder graph.

j. On the RTA set DISPLAY MODE control to RTA FAST and OPER/CAL to OPER. The display oscilloscope will now present the Fourier analysis of the data input signal to 10 kHz.

k. Press the MEMORY HOLD control.

l. Set DISPLAY MODE control to PLOTTER, Sweep Initiation control to SINGLE RESET, and press the SINGLE RESET control. The oscilloscope trace will reset to the left; the SINGLE RESET indicator will not be lighted. If an SDC Model 13116-2A is used as the X-Y Display Oscilloscope, the BLANKING control must be placed to the OFF position to view the trace at the left-hand edge of the display.

m. Energize the X-Y recorder servos and pen-down. (If automatic pen lift is connected to the RTA, pen-down is automatically activated.)

n. Press the SINGLE RESET control. The X-Y recorder will produce a record in the time as internally set and as affected by sweep rate feedback.

At the end of the record, place the X-Y recorder in standby mode.

o. Set DISPLAY MODE control to RTA FAST, Sweep Initiation control to AUTO and press the MEMORY UPDATE control. The analyzer will now accept new data for subsequent displaying and recording.

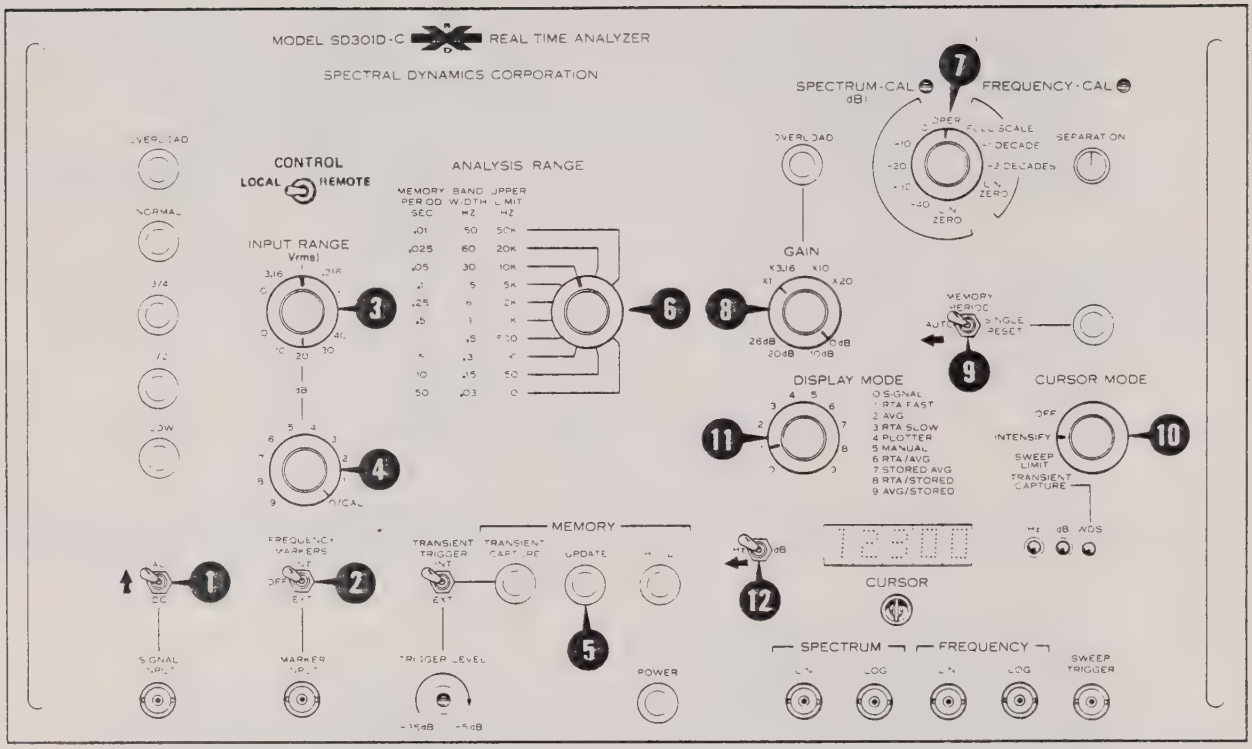


Figure 2-10. RTA Setup for Analysis of a Periodic Signal

LEGEND — RTA Setup for Analysis of a Periodic Signal

STEP	CONTROL/INDICATOR	POSITION
①	AC/DC	AC
②	FREQUENCY MARKERS	OFF
③	INPUT RANGE Coarse Attenuator	1 Vrms
④	INPUT RANGE Fine Attenuator	0/CAL
⑤	UPDATE (Press to light)	LIGHTED
⑥	ANALYSIS RANGE	10 kHz
⑦	OPER/CAL	OPER
⑧	GAIN	X1
⑨	Sweep Initiation	AUTO
⑩	CURSOR MODE	INTENSIFY
⑪	DISPLAY MODE	RTA FAST (Position 1)
⑫	Hz/dB	Hz

2.4.2 Analysis of Acoustic Data

This procedure is given to guide the operator through a typical operational program in the analysis of acoustic data. Specifically, sound pressure level is analyzed using constant-bandwidth filtering. As an example, assume that an on-line analysis is being performed and that a Sound Level Calibrator with an output of 114 dB at 1 kHz is available. Also assume that the output level of the signal conditioning amplifier is 500 mVrms with the above calibration signal applied, based on an output sensitivity of 5 mV per micro bar.

a. Apply power to the RTA, oscilloscope, and X-Y recorder.

b. Connect SPECTRUM LOG output to oscilloscope and recorder Y-Axis inputs; connect FREQ LIN output to oscilloscope and recorder X-AXIS inputs. Refer to Figure 2-3 and the interconnect diagram at the end of this section for RTA setup with the oscilloscope and the X-Y recorder.

NOTE: Linear graph paper with 7 x 10 major divisions is recommended.

c. Adjust the oscilloscope and recorder gain and zero controls as described in the Legends of Figure 2-3 and Figure 2-6. Calibrate the Y-Axis of the oscilloscope and plotter so that each major division change between horizontal graticule lines represents a 10 dB change in output.

d. Set the RTA front panel controls as directed in the Legend of Figure 2-10.

e. Apply the calibration signal from the Sound Level Calibrator to the input of the signal conditioning amplifier and connect the output to the RTA SIGNAL INPUT connector. Observe that the spectrum line at 1 kHz on the display is 6 dB below full scale.

f. Press the MEMORY HOLD control. The calibration signal is now stored in the RTA memory.

g. Remove the Sound Level Calibration signal.

h. Set the DISPLAY MODE control to MANUAL (position 5) and deflect the CURSOR control to tune the RTA to the Calibration signal. When tuned to the calibration signal, the intensified dot will be at the peak of the spectrum line observed in step e. above. The LED readout will indicate the calibration signal frequency.

i. Energize the servo control on the X-Y Recorder. The pen should move to the 1 kHz frequency on the paper. Adjust the Y-Axis Zero control to set the pen on the graph at the point where the 114 dB calibration point is desired.

NOTE: Because the INPUT RANGE and post filter GAIN controls are in the calibration and the operation signal paths, both controls affect the level of the output signal. A change of settings required after calibration must be compensated by a corresponding change of the amplitude (dB) on the X-Y recorder graph.

j. Turn the X-Y recorder servo control off. Turn the DISPLAY MODE control to RTA FAST (position 1).

k. Press the MEMORY UPDATE control. The RTA is now ready to accept acoustic data on the ANALYSIS RANGE selected before calibration.

l. Apply the acoustic data signal to the SIGNAL INPUT connector of the RTA for at least one Memory Period. Press the MEMORY HOLD control. The data is now stored in the RTA Memory. The display on the oscilloscope represents the Fourier analysis of the data input signal over the frequency range selected.

m. Set the DISPLAY MODE control to PLOTTER (position 4). Set the Sweep Initiation control to SINGLE RESET and press the SINGLE RESET control. The oscilloscope trace will reset to the left; the SINGLE RESET indicator will not be lighted.

n. Energize the servo control on the X-Y Recorder. If automatic pen lift control is connected to the RTA, the pen-down mode is automatically activated.

o. Press the SINGLE RESET control. The X-Y recorder will produce a record in the time as internally set and as affected by sweep rate feedback. At the end of the record place the X-Y Recorder in the standby mode.

p. Set the DISPLAY MODE control to RTA FAST (position 1), Sweep Initiation control to AUTO, and depress the MEMORY UPDATE control. The RTA will now accept new data for subsequent displaying and recording.

NOTE: If it is desirable to use the Ensemble Averager to obtain signal-to-noise ratio enhancement, refer to the General Data Averaging description in the Averager manual for the proper interconnect diagram and operation procedure.

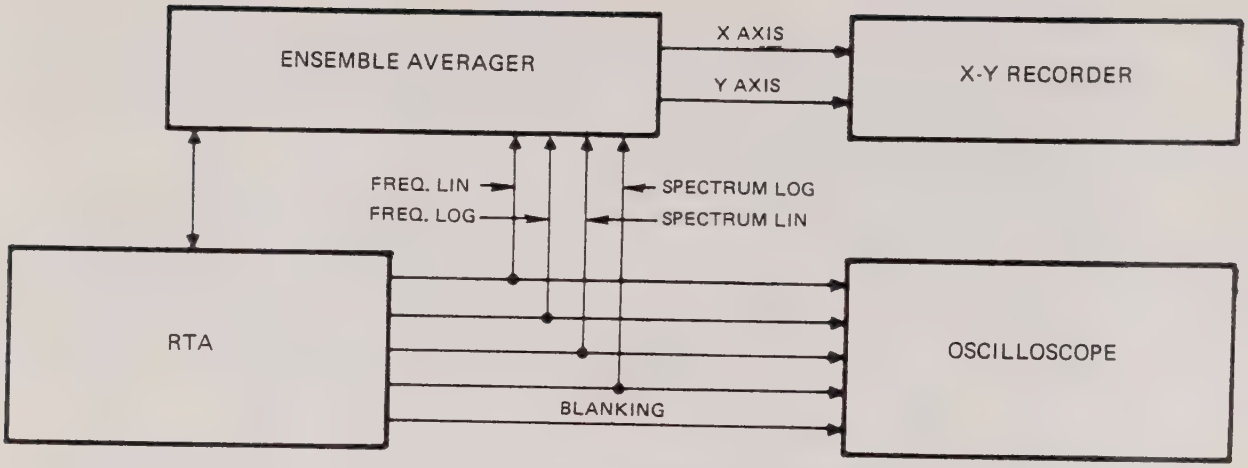


Figure 2-11. RTA Setup for General Data Averaging

2.4.3 Analysis of Random Data (PSD)

2.4.3.1 Introduction

For analyzing signals with random content, an estimate of long-term power spectrum (or power spectral density characteristics) is desired. The RTA performs a complete spectrum analysis in Real Time: that is, each analysis is performed on data with 2 degrees of freedom. The RTA can be used in conjunction with an Ensemble Averager to provide the desired estimate of the average spectrum characteristics of a random signal. The Averager provides frequency domain averaging by examining an ensemble of spectrum functions, and then computing the average sum over a predetermined length of time. Figure 2-11 gives a typical RTA setup with an Averager, an X-Y recorder, and an oscilloscope. Specific Model interconnect diagram can be found at the end of this section.

The accuracy of the average spectral content determined from an ensemble average of spectrum functions is governed by a parameter known as the statistical degrees of freedom (n). This quantity can be computed as $n = 2BT$, where B is the analysis bandwidth and T is the length of time in seconds over which a data sample is examined.

Recall that on any given range of the RTA, the analysis bandwidth, B, is essentially the reciprocal of the memory period, T; thus for all practical purposes, $B = 1/T$. This means that on any range, the product BT is always equal to approximately 1. Since the number of degrees of freedom $n = 2BT$, it is seen that no matter which range of the Real Time Analyzer is selected, each statistically independent spectrum analysis produces a spectrum estimate with two degrees of freedom. Thus, virtually any desired statistical accuracy can be achieved by averaging over a sufficient number of statistically independent memory periods.

A rear-chassis connector J13, on the RTA is wired to accept the interconnection cable from the Ensemble Averager; no changes to the RTA are required. For further details on the operation of the Ensemble Averager, refer to the Instruction Manual for the particular Ensemble Averager and the interconnection diagram at the end of this section.

To establish a calibration level when using the RTA and the Averager combination for PSD analysis, either the internal calibration signal from the RTA or an externally applied calibration signal can be used. Both methods are described in the following paragraphs.

In the examples that follow, a flat random signal in the frequency range of 10 to 2,000 Hz at a level of $0.2\ g^2/Hz$ will be considered. From $g\ rms = \sqrt{g^2/Hz \times BW}$, the overall level of 20 g rms is established. Using the 2K ANALYSIS RANGE, the nominal effective BW is 6.4 Hz. (Refer to Table 2-2.)

2.4.3.2 Understanding the PSD Plot

When measuring random signals, the rms value (or mean squared value) is examined because theoretically the instantaneous peak values can be infinitely high due to the nature of the signal. Also, since the plot represents power (Power Spectral Density or, energy under the curve), it is more meaningful when presented on a squared scale. This is accomplished by calibrating the scale so that a 10 dB voltage change represents a 1-decade change on the graph allowing $volts^2$ or g^2 to be plotted (directly governed by $dB = 10 \log P1/P2$). The term g^2/Hz is used to define a level of random acceleration and is independent of bandwidth. But, when an analyzer is prepared for measurement of random data, analyzer bandwidth is a part of the calibration formula, and is therefore compensated for. A plot of g^2/Hz over

Table 2-2. Memory Parameters

Analysis Range Upper Limits (Hz)	Bandwidth (Hz) (3 dB Filter)	*Resolution (Hz)	Nominal **Effective (Noise) Bandwidth (Hz)	Measured Effective (Noise) Bandwidth (Hz)
50,000	150	100	160	
20,000	60	40	64	
10,000	30	20	32	
5,000	15	10	16	
2,000	6	4	6.4	
1,000	3	2	3.2	
500	1.50	1	1.6	
100	0.30	0.20	0.32	
50	0.15	0.10	0.16	
10	0.03	0.02	0.032	

*Spacing of filter locations.

**If maximum accuracy is required, the effective (noise) bandwidth should be determined by measurement. Refer to Paragraph 2.4.3.5 for recommended procedure.

some frequency range is then meaningful, even when going from analyzer to analyzer or when changing ranges of the analyzer. The frequency resolution may vary but the "shape" or plot profile will remain the same.

Figure 2-12 shows a typical test requirement in which a profile of energy distribution is specified. The dashed lines indicate upper and lower tolerance levels that typically are ±3 dB. However, with respect to these

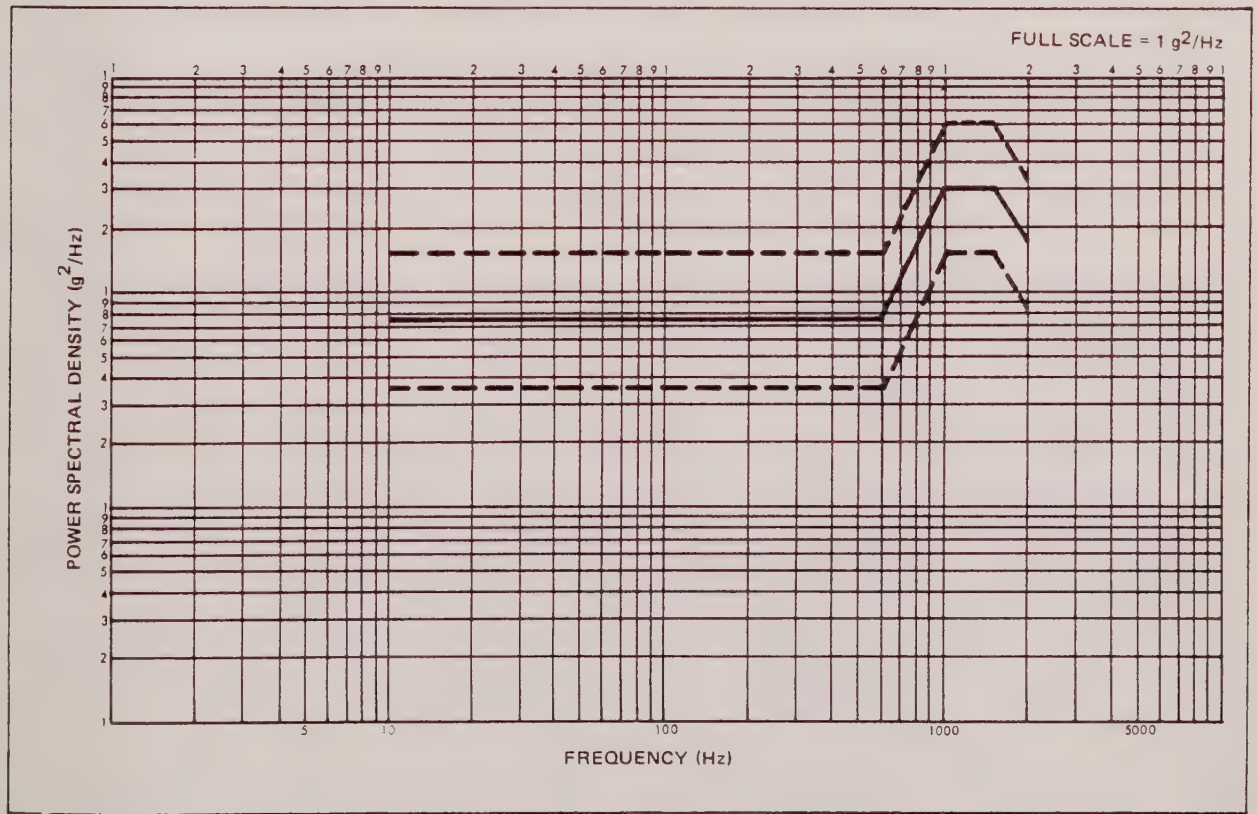


Figure 2-12. Typical Test Requirement for a Profile of Power Spectral Density

tolerance levels, there is a governing factor because +3 dB is double the test level and such a deviation is not the intention of the test engineer. This factor is that the overall g rms test level is given a tolerance of ±10 percent, as read on a broadband true rms meter. Typical test specifications state that the g^2/Hz level can exceed the ±3 dB limits as long as the frequency band in which the excursion occurs is less than 300-Hz wide and if the overall g rms level remains within ±10 percent. Some examples for reading a PSD plot are given in Figures 2-13 and 2-14 with the accompanying explanation.

Figure 2-13 shows how the overall g rms level can be determined for this "shaped" spectrum. The solution is not presented in detail but it can be derived by finding the g rms levels of each of the sections ① through ⑤ using g rms $= \sqrt{g^2/Hz \times BW}$. In sections ④ and ⑤ only half of the measured BW should be used in the formula since the level follows a curve. The total or overall level is then found as the square root of the sums of the squares of the levels determined for each section. This will give a close approximation since, as stated above, the levels in sections ④ and ⑤ follow a curve. On the log scale the lines are straight but on a linear scale the lines are curved and asymptotic to 6 dB/octave.

Another common test (Figure 2-14 requires that a 20 g rms random signal, over the range of 10 Hz to 2,000 Hz, be mixed with a 10 g peak sine wave at 1 kHz. To keep everything in equal terms, the rms value of the sine wave is found and the level of the sine wave, as seen by the analyzer (based on its filter bandwidth) must then be found. Perform this task as follows:

a. Determine rms g level of sine component:

$$10 \text{ g peak} \times 0.707 = 7.07 \text{ g rms}$$

b. Determine overall test level to be read:

$$\text{g rms overall} = \sqrt{\text{random level}^2 + \text{sine level}^2}$$

$$= \sqrt{400 + 50}$$

$$= 21.2$$

c. Determine the g^2/Hz level of the random signal:

$$g^2/Hz = \frac{(\text{g rms})^2}{BW}$$

$$= \frac{400}{1990}$$

$$= 0.201$$

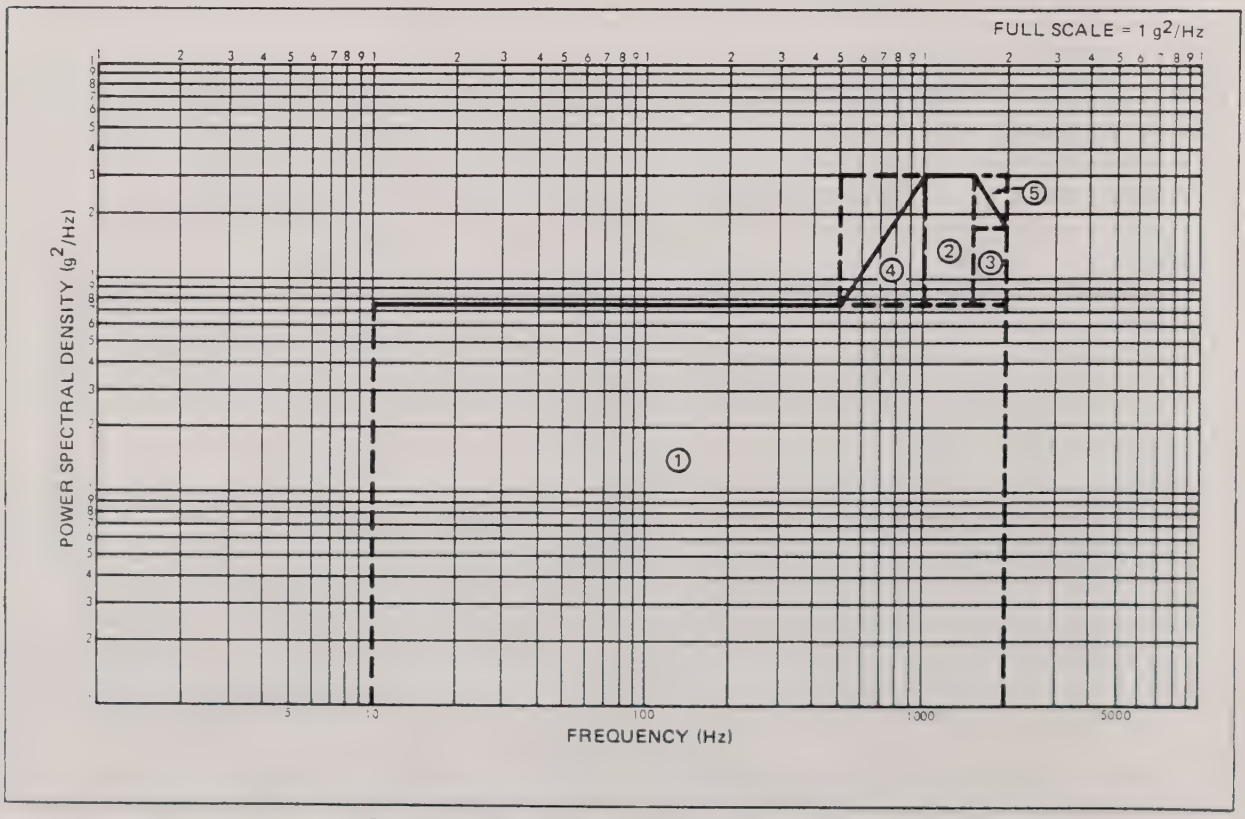


Figure 2-13. Determination of Overall g rms Level

d. Determine the g^2/Hz level of sine wave (dependent on analyzer filter bandwidth):

$$g^2/Hz = \frac{(g\ rms)^2}{BW}$$

$$= \frac{50}{6.4}$$

$$= 7.812$$

e. Determine the combined g^2/Hz level to be read on the X-Y plot at 1 kHz:

g^2/Hz (random) = 0.201

g^2/Hz (sine) = 7.812

Total = 8.01

2.4.3.3 PSD Calibration Using Internal Cal Signal

Assume that the random data sample of 20g rms is on-line and is based on a known sensitivity of 10 mV rms/g rms. The following steps are employed for calibration with an X-Y recorder.

a. Interconnect the RTA and the Averager using the diagram shown in Figure 2-11 as a guide. Apply power to the RTA and all associated instrumentation equipment. (Refer to Paragraph 2.1 for powering procedure.)

NOTE: Graph paper with a 2 or 3 decade log scale for amplitude should be used. The frequency axis can be lin or log as desired.

b. Calibrate the X and Y axis of the recorder as described in the Legend, Figure 2-6 for lin or log frequency and log spectrum except calibrate the Y axis so that a 10 dB voltage change produces a 1 decade change on the chart to establish a two times the log (or g^2) condition.

c. Set the RTA front-panel controls as given in the Legend, Figure 2-10 with the exception of the ANALYSIS RANGE control. Set the ANALYSIS RANGE to 2K.

d. Apply the data signal to the SIGNAL INPUT (front panel or J24 rear connector) to enable presetting the following operating parameters. Set the INPUT RANGE control to .316 Vrms and the 1 dB attenuator for an input level indication which shows only occasional input

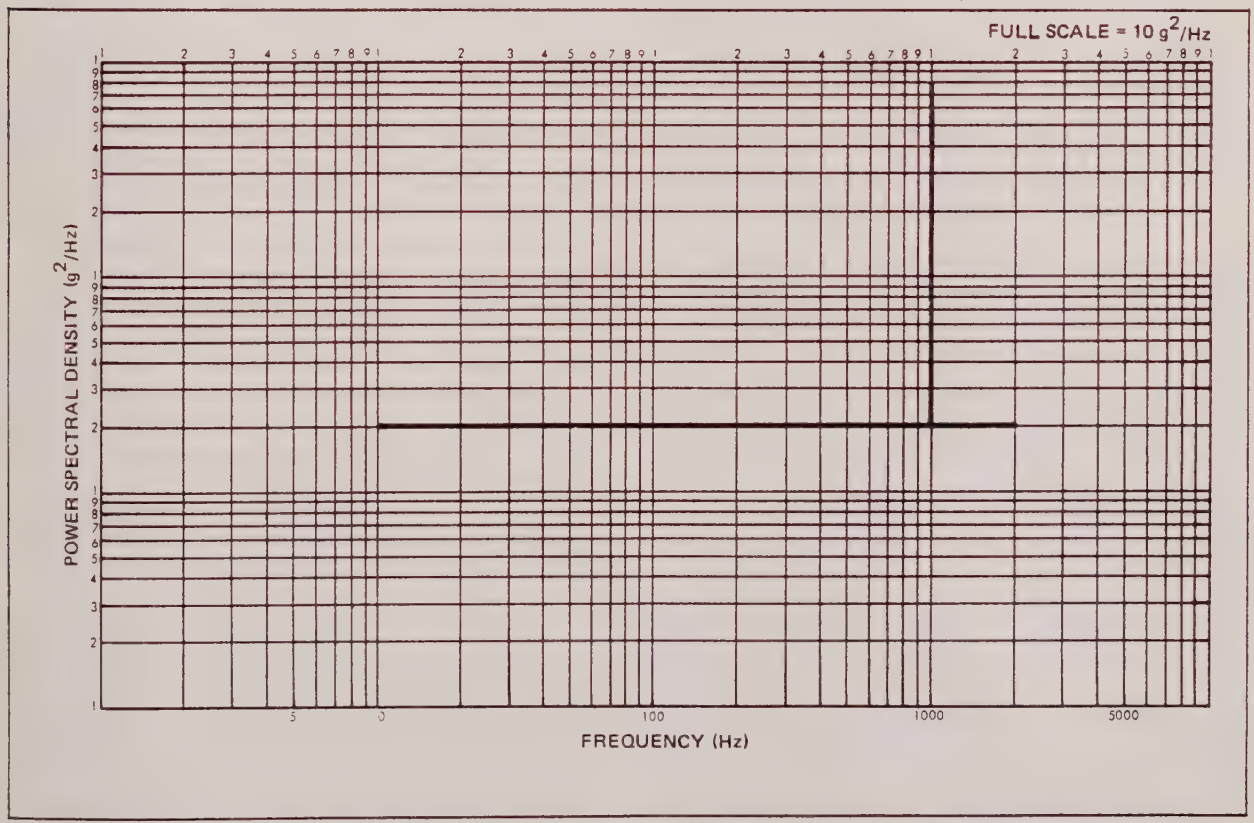


Figure 2-14. Typical Test Requirement Showing a Flat PSD Spectrum Combined with a Periodic Signal

Table 2-3. PSD Calibration Values

ANALYSIS RANGE	NOISE* BW (Hz)	INPUT RANGE Vrms				
		0.1	.316	1.0	3.16	10
50K	160	7.98×10^{-1}	7.98×10^{0}	7.98×10^{1}	7.98×10^{2}	7.98×10^{3}
20K	64	1.99×10^{0}	1.99×10^{1}	1.99×10^{2}	1.99×10^{3}	1.99×10^{4}
10K	32	3.99×10^{0}	3.99×10^{1}	3.99×10^{2}	3.99×10^{3}	3.99×10^{4}
5K	16	7.98×10^{0}	7.98×10^{1}	7.98×10^{2}	7.98×10^{3}	7.98×10^{4}
2K	6.4	1.99×10^{1}	1.99×10^{2}	1.99×10^{3}	1.99×10^{4}	1.99×10^{5}
1K	3.2	3.99×10^{1}	3.99×10^{2}	3.99×10^{3}	3.99×10^{4}	3.99×10^{5}
500	1.6	7.98×10^{1}	7.98×10^{2}	7.98×10^{3}	7.98×10^{4}	7.98×10^{5}
100	0.32	3.99×10^{2}	3.99×10^{3}	3.99×10^{4}	3.99×10^{5}	3.99×10^{6}
50	0.16	7.98×10^{2}	7.98×10^{3}	7.98×10^{4}	7.98×10^{5}	7.98×10^{6}
10	0.032	3.99×10^{3}	3.99×10^{4}	3.99×10^{5}	3.99×10^{6}	3.99×10^{7}

overload conditions. Increase the post filter GAIN to X10, 20 or 26 dB gain being certain that OUTPUT overload conditions are not experienced. This permits full use of the dynamic range of the RTA to obtain the optimum for random signal or transient analysis.

CAUTION

Both the INPUT RANGE fine attenuator and post filter GAIN controls are in the calibration signal "path," and, therefore, affect the output signal level. If they cannot be preset using the actual data signal, any change of settings required after calibration must be compensated for by a corresponding change in dB on the recorder graph.

e. Establish the SPECTRUM-CAL setting as follows:

$$CAL = \frac{(grms \times 1.13)^2}{\text{Effective BW (from Table 2-2)}}$$

NOTE: The factor of 1.13 is used since the RTA employs quasi-peak* detection. The resulting relationship of random = 1.13 times rms sine must therefore be considered when calibrating with a sine wave. The nominal effective BW on the 2-kHz analysis range is 6.4 Hz.

*quasi-peak = envelope rectifier followed by sampling detector.

Therefore:
$$CAL = \frac{(31.6 \times 1.13)^2}{6.4}$$
$$= \frac{1273.5}{6.4}$$
$$= 199.0\ g^2/Hz$$

The Cal equation in Step e. of Paragraph 2.4.3.3 was used to develop the 0 dB g^2/Hz calibration values for an INPUT SIGNAL normalized to 10 mV/g for all the INPUT RANGES and corresponding ANALYSIS RANGES on the RTA. These are presented in Table 2-3.

*NOTE: The nominal noise bandwidth (Hz) was used to compute the g^2/Hz 0 dB calibration values in Table 2-3. If maximum accuracy is required, the effective noise bandwidth should be determined by measurement and the g^2/Hz 0 dB calibration values corrected accordingly. Refer to Paragraph 2.4.3.5 for recommended procedure.

f. Set the DISPLAY MODE control to PLOTTER (position 4) and set the Averager to the SCOPE mode.

g. Set OPER/CAL control to SPECTRUM-CAL -30 dB, energize the recorder servo, and adjust the Y axis of the recorder using the zero adjust so that the pen lines up with 0.199 g^2/Hz in the upper decade of the graph. (The data level is expected to be 0.2 g^2/Hz.) After adjusting the recorder, place it in standby; then set the OPER/CAL control to OPER and the DISPLAY MODE control to AVG (Position 2).

NOTE: 1) If sweep rate feedback is desired on the Averager, refer to the Averager manual for connection details.
2) On Averager rear chassis, select LIN or LOG frequency on PLOTTER outputs.
3) For automatic pen lift connection details, refer to Paragraph 2.3.3.

h. On the Averager select the LIN AVG mode and the desired NO. OF ENSEMBLES to be averaged. With the random data signal being applied to the input of the RTA, press the ERASE and the AVERAGING START control. Refer to the Averager manual for more information on General Data Averaging.

NOTE: The duration that the data signal must be applied is a function of the product of the MEMORY PERIOD and the chosen NO. OF ENSEMBLES. For example, in the 2-kHz analysis range, the memory period is 0.25 seconds. If 64 ensembles are to be averaged, the data signal must be applied for a minimum duration of 16 seconds. The AVERAGING STOP control/indicator indicates the completion of averaging.

i. Upon completion of the averaging, engage the servo section of the X-Y recorder and refer to the Ensemble Averager manual for Plotter Operation. The record will be produced in the time as selected and as affected by sweep rate feedback.

2.4.3.4 PSD Calibration Using Tape Recorded Cal Signal

If a tape recorded calibration signal is available that is representative of a known g rms level, the calibration procedure is the same as Paragraph 2.4.3.3 except Steps e., f., and g. (substitute steps are given below).

The example used in this procedure assumes that a 1-kHz sine wave calibration signal at a level representing 20g rms has been recorded along with the example 20g rms random data signal. To calibrate, perform Steps a. through d. of Paragraph 2.4.3.3, then proceed as follows:

SUBSTITUTE for Step e.

Establish the CAL g^2/Hz level as follows:

Measure the rms level of the recorded calibration signal to determine the tape recorder sensitivity (or the data signal sensitivity). For this example, assume that 200 mV rms was measured.

$$\text{Signal Sensitivity} = \frac{\text{Tape Output Level}}{\text{Calibration Level}}$$

$$= \frac{200 \text{ mV rms}}{20 \text{ grms}}$$

$$= 10 \text{ mV/g}$$

Determine the g^2/Hz CAL level:

$$\text{CAL} = \frac{(\text{g rms} \times 1.13)^2}{\text{Effective BW (See Table 2-2)}}$$

$$= \frac{(20 \times 1.13)^2}{6.4}$$

$$= 79.9 \; g^2/\text{Hz}$$

Now determine the INPUT RANGE control setting required for the calibration signal. Because the data signal measured 200 mV rms, during data analysis the INPUT RANGE control would be set to .316 Vrms. However, the calibration signal is 20 dB higher (79.9 g^2/Hz versus 0.2 g^2/Hz), so for this example the INPUT RANGE control would be set to 3.16 Vrms while calibrating.

SUBSTITUTE for Steps f. and g.

Set the OPER/CAL control to OPER and DISPLAY MODE control to MANUAL. On the AVERAGER set the DISPLAY control to PLTR RATE and depress the RESET push button. Using the Cursor Locator control, tune the RTA to 1 kHz. Ensure signal level is at the "peak" of the filter; observe the pen level on X-Y recorder while tuning.

Using the recorder zero adjust, calibrate the Y-axis so pen lines up with 0.799 g^2/Hz in the upper decade of the graph.

After the recorder is calibrated, place it in the Standby mode. On the RTA, set INPUT RANGE control to 0.316 Vrms and DISPLAY MODE control to AVG (Position 2). Set DISPLAY control on the AVERAGER to the SCOPE position.

Perform Steps h. and i. of Paragraph 2.4.3.3.

2.4.3.5 Determining Effective Noise Bandwidth for Analysis

Effective square (or noise) bandwidths become important in power spectrum analysis because measured spectrum levels are squared values (and thus the shape of the analysis filter is essentially squared in terms of the resulting spectrum display).

The actual filter bandwidth in a Real Time Analyzer is dependent upon filter width, filter shaping networks, and weighting function adjustments. Therefore, each analyzer has its particular effective noise bandwidth which may vary slightly from the nominal value.

Table 2-2 lists the effective squared bandwidth (nominal value) for each analysis range of a typical Real Time Analyzer. However, before commencing a program of power spectrum measurements, it is recommended that a measurement be made of the filter on the analysis range to be used. Several techniques are available for performing this measurement; one involves plotting the actual filter shape, squaring the resulting ordinate values and determining the area under the curve or the "effective squared bandwidth." A simpler approach is possible if the necessary equipment is available to the operator. (See Figure 2-15.) The accuracy of this technique is only as good as the ability of the operator to develop a flat random profile with a known bandwidth, and to read the g rms indication on an TRMS meter.

The simpler approach requires an easy manipulation of the calibration equation for power spectrum analysis given in Paragraph 2.4.3.3, Step e. (The calibration equation states that

$$\text{Cal } g^2/\text{Hz} = \frac{(\text{g rms} \times 1.13)^2}{\text{effective BW}} .)$$

The procedure for this technique involves the following basic steps:

1. A relative calibration level (in terms of span and offset on an X-Y recorder) is established.

2. A known power spectrum (g^2/Hz) level is established.

3. The sinusoidal level equivalent to the power spectrum level established in Step 2 above is substituted.

For example, by using one of the test setups illustrated in Figure 2-15, a random noise signal (limited to a 10-Hz to 2-kHz band) is established. If the level of this signal is set to 100 mV rms, a known power spectrum is established. And, if a sensitivity of 10 mV rms/g rms is assumed, the established level corresponds to a test level of 10g rms over the selected 2-kHz bandwidth. The test level therefore corresponds to a known spectrum level of 0.05 g^2/Hz

$$(g^2/\text{Hz} = \frac{\text{g rms}^2}{\text{data BW}}).$$

The internal calibration signal of the RTA can then be used to establish the span of the X-Y recorder. Continue in accordance with the following procedure:

a. Set the span so that a 10 dB change in RTA input signal produces a 1-decade power output display on the X-Y recorder.

NOTE: At this point in the procedure, it is not important where the zero point is set, but it is important that a true dB/decade relationship has been established.

b. Apply the 100 mV random signal to the RTA. Set the RTA ANALYSIS RANGE selector to the 2K position.

NOTE: If the analysis procedure is performed correctly (without overload, but with sufficient input and output gain), a power spectrum display with either 64 or 128 averages will represent a smooth spectrum shape.

c. Record the spectrum on the X-Y recorder with the zero adjustment of the recorder set so that the spectrum is displayed in the top decade of the graph.

d. Remove the random noise signal and apply a 1-kHz (approximate) sine wave signal. Tune the analyzer to the exact frequency of the sine wave by selecting the MANUAL mode (position 5) and using the CURSOR Control.

NOTE: In the following step, vary the oscillator frequency slightly to ensure that it is at the "peak" of the filter while making the final level adjustment.

e. Adjust the level of the sine wave until the recorder pen reaches the same level as the flat portion of the spectrum recorded in Step c. above. This establishes an equivalent power spectrum level. The level of the input sine wave now corresponds to an equivalent power spectrum level of 0.05g rms^2/Hz.

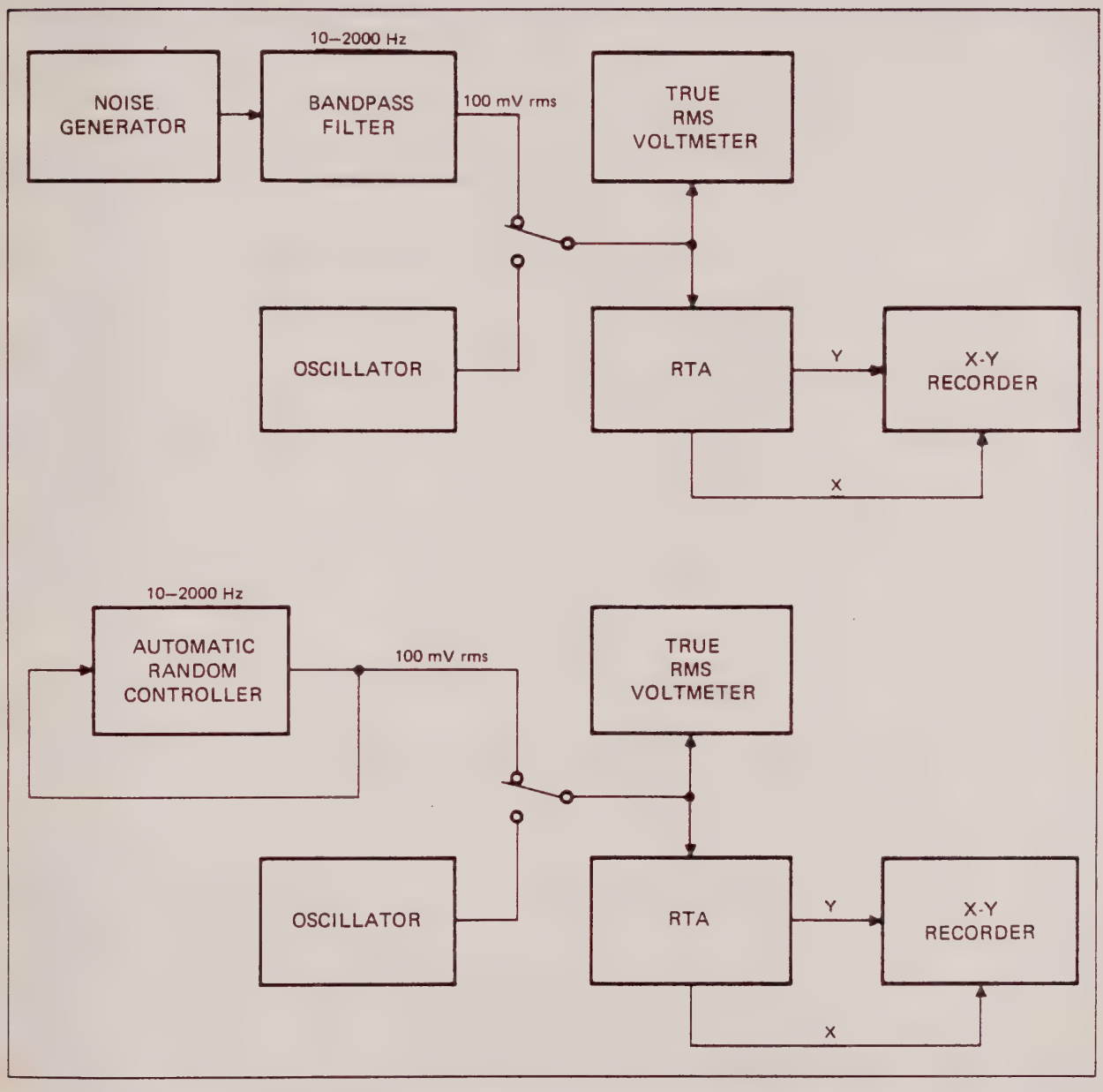


Figure 2-15. Two Test Setups Used for Determining Effective (Noise) Bandwidth

f. With the rms voltmeter, measure the sine wave level required to bring the recorder pen to the level specified in Step e. above. The operator can now quickly establish the following calibration equations: (Assume for this example that the rms voltmeter indicates a level of 5.3 mV rms.)

$$\text{Cal } g^2/\text{Hz} = \frac{(g \text{ rms} \times 1.13)^2}{\text{effective BW}}$$

In the above equation, all terms are known quantities except effective squared bandwidth for which the equation can be rewritten as:

$$\text{Effective BW} = \frac{(0.52 \text{ g rms} \times 1.13)^2}{0.05} = 6.9 \text{ Hz}$$

The result of this computation is a direct indication of effective squared bandwidth for the filter of the 2-kHz analysis range.

2.4.4 Transient Analysis

2.4.4.1 Introduction

The RTA has the capability of performing Fourier analysis of a transient signal whose time duration is less than one memory period on any selected analysis range. After the transient has been captured in the analyzer memory, its spectrum is displayed repetitively for a flicker-free oscilloscope display or recorded on an X-Y recorder for permanent record.

All Fourier process analyzers have constraints on the spectrum analysis of transient signals such as bandwidth, weighting function effects, and frequency resolution. Proper assessment of the constraints can simplify the spectrum interpretation of the transient analysis.

Assuming that the signal spectrum of a time function is not changing with time, the frequency resolution attainable in the Fourier spectrum analysis is inversely proportional to the time duration of the signal which is processed in the analyzer memory. This can be expressed in the form

$$\text{Freq Resolution (Hz)} = \frac{1}{\text{Time Duration of Signal in Memory}}$$

This is a very useful relationship in transient analysis because it establishes what frequency resolution is attainable when signals that occupy less than one memory period are being analyzed.

A practical illustration of this is the Fourier spectrum analysis of a burst of a sine wave shown in Figure 2-16.

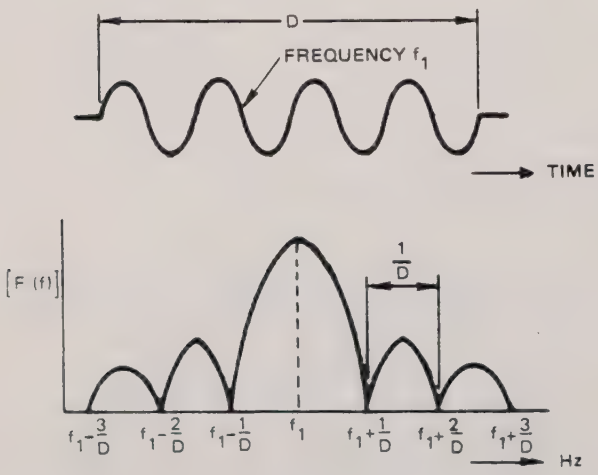


Figure 2-16. Fourier Transform of a Truncated Sine Wave

The attainable frequency resolution of the signal in Figure 2-16 is Δf.

$$\Delta f \text{ (Hz)} = 1/D$$

The magnitude of the Fourier transform of this finite duration signal has the form of the classical sin x/x function.

2.4.4.2 Capturing the Transient

Since the RTA has the basic capability for capturing and storing data, it can serve as a transient recorder. A speeded-up replica of the input time function, with low pass filtering added, is continuously recirculated in digital memory for monitoring or photographing. Virtually any standard laboratory oscilloscope with at least 5 MHz frequency response is turned into a storage scope since the stored data is outputted on a continuous basis.

a. Interconnect the instruments as shown in Figure 2-17 for viewing RTA memory contents and the spectrum of the transient signal. Refer to interconnection diagram at the end of this section.

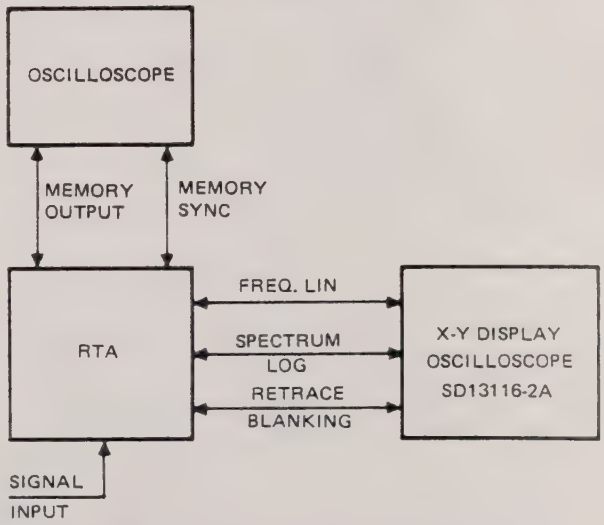


Figure 2-17. Setup for Viewing Memory Contents and Signal Spectrum

b. Apply power to the RTA and external oscilloscopes.

c. Set the time base generator on the oscilloscope for viewing the Memory contents to 10 μsec/division and adjust the trigger to accept the RTA Memory Sync pulse.

NOTE: One circulation period of the RTA digital memory is 100 μsec. Thus, one Memory Period is displayed on the oscilloscope and this presentation is rapidly changing when the RTA is not in the HOLD mode.

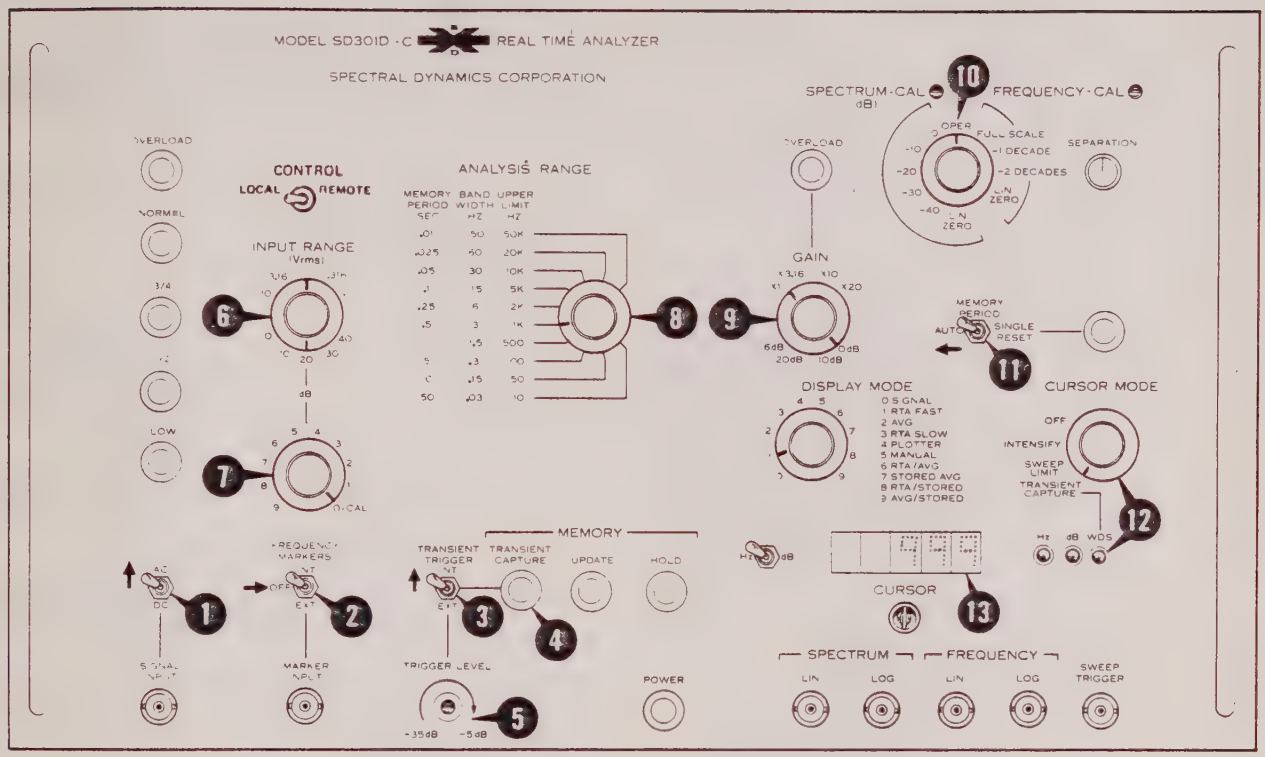


Figure 2-18. RTA Setup for Transient Analysis

LEGEND – Setup for Transient Analysis

	Control	Position
①	AC/DC	AC
②	FREQ MARKERS	OFF
③	TRANSIENT TRIGGER	INT
④	TRANSIENT CAPTURE (Press to light)	LIGHTED
⑤	TRIGGER LEVEL (Adjust until the RTA is not triggered by spurious noise)	
⑥	INPUT RANGE Coarse Attenautor	1 Vrms
⑦	INPUT RANGE Fine Attenuator	0/CAL
⑧	ANALYSIS RANGE	1 kHz
⑨	GAIN	X1
⑩	OPER/CAL	OPER
⑪	Sweep Initiation	AUTO
⑫	CURSOR MODE	TRANSIENT CAPTURE WDS light on
⑬	DISPLAY MODE	RTA FAST (Position 1)
⑭	CURSOR	Select 999 WDS on Cursor Readout

Set the oscilloscope vertical amplifier for 100 mV/division, AC coupled.

d. Set the RTA front-panel controls as described in the Legend of Figure 2-18, Setup for Transient Analysis.

e. Apply a 1 Vrms 500 Hz data signal to the RTA SIGNAL INPUT connector. The Input OVERLOAD indicator should be extinguished.

NOTE: 1) With the RTA set up for Transient Analysis per the Legend of Figure 2-18, 999 samples of the input signal will load into memory after the signal exceeds the threshold level to generate the transient capture trigger. Upon completion of loading, the HOLD indicator will light and the oscilloscope will display the stored data signal.
2) A built-in delay in the MEMORY SYNC signal allows the START/STOP point of the data in memory to be displaced from the right edge of the display. Figure 2-19 shows how to interpret the oscilloscope display.

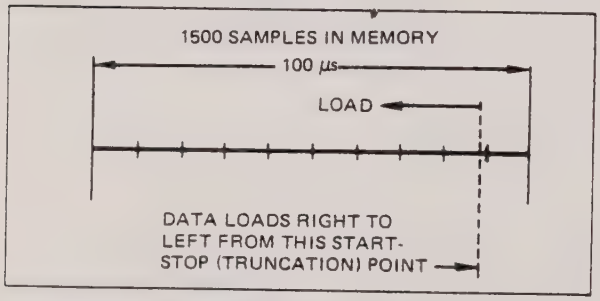


Figure 2-19. Oscilloscope Display Showing Approximate Truncation Zone as Determined by Oscilloscope Trigger Setting

f. For normal operation of the TRANSIENT CAPTURE mode, the CURSOR MODE control is set to the TRANSIENT CAPTURE position. The number of samples to be loaded into memory (001 to 999) is selected by the CURSOR control and displayed on the LED readout.

If the CURSOR MODE is not set to TRANSIENT CAPTURE, 1500 data samples are loaded into memory. This is not an optimum condition for transient analysis because of the attenuation characteristics introduced by the weighting function. The weighting function is required in an analyzer with a finite memory to eliminate possible truncation errors at the beginning and end of the memory.

In the TRANSIENT CAPTURE Mode the attenuation effects of the weighting function are minimized by using only 2/3 of any selected memory period. It is recommended that the transient occupy the center 1/3 of the memory if the maximum amplitude of the spectrum response is to be realized. Data can be loaded in the front 1/3 of the memory but, again, attenuation effects of the weighting function will affect the spectrum response. A typical weighting function curve is shown in Figure 2-20.

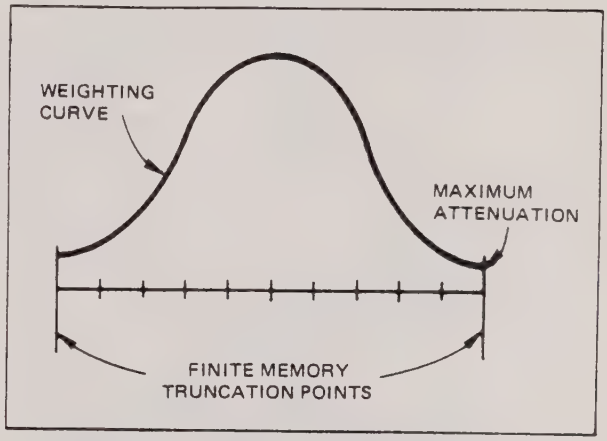


Figure 2-20. Effect of Weighting Function

2.4.5 Analysis of Rotating Machinery

2.4.5.1 Introduction

This procedure for analysis of rotating machinery guides the operator through a typical operation in which an X-Y recorder is used and, as an option, an SDC Signature Ratio® Adapter is used.

There are two meaningful techniques for analyzing rotating machinery with the RTA. One technique employs the RTA as a stand-alone instrument. In this case the procedure is the same as that given in Paragraph 2.4.1 for analysis of a periodic signal. To help interpret the display thus obtained, consider the following: All vibration components (spectrum lines on the display) related to rpm will change frequency as speed changes occur. Structural resonances will remain fixed in frequency, since they are independent of rotational frequency. Start up may excite a structural resonance if it has a component related to the resonant frequency. The amplitude of the structural resonance will increase as the frequency of the exciting component passes through the frequency of the resonance. Moreover, if the vibration amplitude increases for extended periods at critical frequencies, destruction can result.

Table 2-4 contains information provided as a guide for identifying sources of vibration and noise. This data is not complete due to the depth of the subject, but is of value in making preliminary investigations.

Table 2-4. Frequencies for Identifying Vibration and Noise Sources

GEARS

- Input Shaft Speed in Hz = $\frac{\text{Run Speed RPM}}{\text{60 Hz/min}}$
- Gear Mesh Frequency = Shaft Speed x No. of Teeth
- No. 2 Shaft Speed Frequency = $\frac{\text{Gear Mesh Frequency}}{\text{No. of Teeth (No. 2 Gear)}}$
- First Upper Sideband Frequency = Gear Mesh + Input Shaft Speed
- First Lower Sideband Frequency = Gear Mesh – Input Shaft Speed

BEARINGS

- Element Spin Frequency = $f_d \left(\frac{D_I}{D_I + D_O}\right) \left(\frac{D_O}{D_E}\right)$
- Element Train Passage Frequency = $f_d D_I$
- Rough Spot on Element Frequency = 2 x Element Spin Frequency
- Rough Spot on Inner Race Frequency = $f_d N D_O$
- Rough Spot on Outer Race Frequency = $f_d N D_I$

where:

N = No. of Elements
D_I = Diameter of Inner Race
D_O = Diameter of Outer Race
D_E = Diameter of Elements
f_d = Frequency Differential between Inner and Outer Race

MISCELLANEOUS VIBRATION

- Unbalance Frequency = 1 x Shaft Speed
- Misalignment Frequency = 2 x Shaft Speed
- Oil Whip Frequency = 1/2 x Shaft Speed
- Impeller Vanes Passage Frequency = No. Vanes x Shaft Speed
- Turbine Blades Passage Frequency = No. Blades x Shaft Speed

The other meaningful technique for analyzing rotating machinery with the RTA provides for a frequency scale that is normalized to order-related multiples of operating speed. This technique requires use of an SDC Signature Ratio® Adapter as an accessory instrument. The SRA has provisions for operate/bypass modes, selection of input voltage range in volts rms, tachometer repetition rate in pulses per revolution, maximum order to be displayed, and a tachometer sensitivity adjustment.

In the operate mode, the SRA provides a filtered data signal and a sampling pulse signal for input to the RTA. Refer to the SRA instruction manual for specific details including a discussion of operating range and front-panel controls.

One of the SRA operational modes is described in Paragraph 2.4.5.2.

2.4.5.2 Signature Ratio® Analysis

This procedure describes the instrument setup and operation required to obtain an oscilloscope display and X-Y recording on which the frequency range is determined by the SRA to maintain order-related data.

a. Apply power to the RTA, SRA and X-Y recorder.

b. Connect instruments as shown in Figure 2-21. Refer to the SRA instruction manual for data concerning special cables and to interconnection diagram at the end of this section.

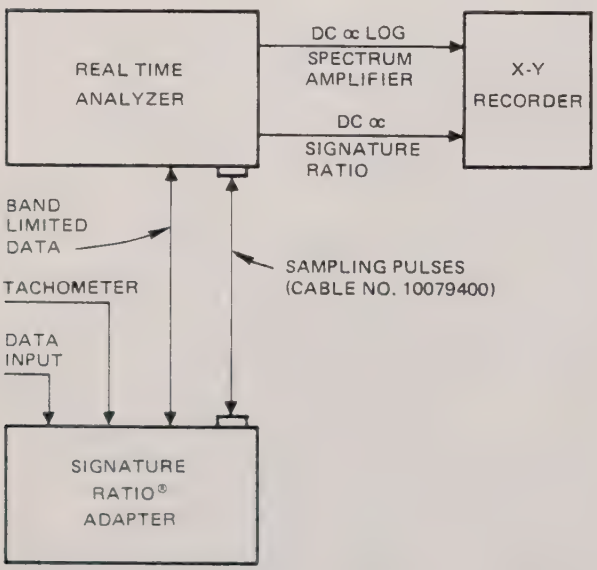


Figure 2-21. RTA Setup for Signature Ratio® Analysis

c. Set the Mode Control to the BYPASS position of the Signature Ratio Adapter.

d. Perform the Steps b. through i. of Paragraph 2.4.1.

e. On the SRA set the INPUT RANGE Vrms to the same range determined by the RTA control setting for the INPUT RANGE Coarse Attenuator in Step e., Paragraph 2.4.1.

f. On the SRA select a TACH FREQ RANGE (Hz). Use the TACH PULSES/REV rate and the desired MAX ORDERS number to determine the required rate K value.

$$K = \frac{P/R \times M}{\text{MAX ORDER}}$$

Set the K value on the 3-digit thumbwheel switch.

g. Set the FILTER MODE control to the OPER mode and the FILTER (Hz) Limit control to the 50–5K position. If the Filter limit light is on, set the FILTER (Hz) Limit control to a range which will accept the highest frequency of the maximum order displayed during the test run.

h. Set the INPUT RANGE Vrms control on the RTA to the 0.316 Vrms range.

NOTE: The level of the full-scale filtered signal output from the SRA is 0.316 Vrms. Therefore the calibration amplitude determined by Paragraph 2.4.1 is maintained by performing Steps e. and h. above. However if the SRA OVERLOAD indicator lights during this procedure after performing Step g. above, press the next higher range (Vrms) push button on the SRA and make a corresponding change on the scales of the display oscilloscope and the X-Y Recorder.

i. On the RTA set the ANALYSIS RANGE selector to the maximum upper frequency range.

j. With the machinery operating adjust the SRA TACH SENSITIVITY control until a TRIGGER acquired light is obtained.

k. With the machinery operating to produce the desired spectrum display, perform Steps k. through o. of Paragraph 2.4.1. Note that the resulting X-Y record has the X-Axis displayed in terms of the selected MAX ORDER of the machinery running speed.

2.5 RTA Accessory Instruments and Interconnect Diagrams.

The following section contains a list of accessory instruments for the RTA, see Table 2-5. Interconnection diagrams for specific models with the RTA are given beginning with Figure 2-22. Functions for the multipin connectors J13, J14, and J15 are given in Tables 2-6, 2-7 and 2-8. Functions for the multipin connector, J30, are given in Table 2-9.

Table 2-5. RTA Accessory Instruments

ACCESSORY	APPLICATION				
	Acoustic and Pass-by Studies	Signal-to-Noise Enhancement	Frequency Translation	Machinery Analysis	Display Readout
SD303 Spectrum Translator			•		
SD304 Signature Ratio® Adapter				•	
SD305A Octave Converter	•				
SD306 Signature Ratio® Adapter				•	
SD307 Spectrum Translator		•	•		
SD308 Signature Ratio® Adapter				•	
SD309 Ensemble Averager		•			
SD331 Automatic Balancing Adapter				•	
SD332 Spectrum Translator		•	•		
SD45 Memory					•
SD46 Memory					•
SD25-80-1 3-D Display Control					•
SD25-87 Output Control Unit				•	
SD25-91A Sweep Limit Control					•
SD25-104A Spectrum Line/Order Tracker				•	
SD25-123 Trigger Delay Unit					•
SD25-132 Overall Level Detector	•				
SD25-140 Paper Tape Control					•
13116-2A X-Y Display (Scope)	•	•	•	•	•
13151 Spectrogram Display Control		•		•	
13178 Time-Gram Adaptor		•			
13175-3/13176A Hard Copy Adapter/Printer		•			•
13185 Vibration Monitor/Analyzer Control				•	
13202 Vibration Monitor/Analyzer Control				•	

Individual data sheets on each accessory unit are available from the factory or from Spectral Dynamics District Offices and Sales Representatives.

Table 2-6. J13 Connector Functions

Pin	Function
1	Spare
2	Spare
3	S (Sweep in PLOTTER Mode) to RTA
4	RTA Sweep to RTA
5	LIN STEP Spectrum from RTA
6	LIN STEP Frequency to RTA
7	AR (10 kHz, 20 kHz, 50 kHz) from RTA
8	Spare
9	Averaged LIN STEP Spectrum to RTA
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare
16	Spare
17	+5V from RTA
18	Spare
19	Ground
20	Ground
21	Ground
22	Ground
23	Ground
24	Indication to RTA
25	Reset Sampling Counter to RTA
26	Gated Step from RTA
27	Plotter Sweep from RTA
28	RTA Sweep from RTA
29	Memory Period from RTA
30	Gated Step to RTA
31	Plotter Reset to RTA
32	Spect-Cal. Sel No of Avg. Lin Avg
33	Lin Step Freq from RTA
34	300* from RTA
35	Spec Cal from RTA
36	Select 1 kHz range from S1A (RTA)

Table 2-7. J14 Connector Functions

Pin	Function
1	Ground
2	Ground (to enable external Range control) to RTA
3	Select 10 Hz Range from S1A (RTA)
4	Select 100 Hz Range from S1A (RTA)
5	Select 2 kHz Range from S1A (RTA)
6	Select 10 kHz Range from S1A (RTA)
7	10 kHz, 20 kHz, or 50 kHz Range Selected from RTA
8	Spare
9	Spare
10	Spare
11	Spare
12	Spare
13	Select 50 kHz Range from S1A (RTA)
14	Spare
15	Spare
16	Spare
17	Spare
18	Remote Freq Offset to RTA
19	Ground
20	External Sample Input to RTA
21	Select 50 Hz Range from S1A (RTA)
22	Select 500 Hz Range from S1A (RTA)
23	Select 5 kHz Range from S1A (RTA)
24	Select 20 kHz Range from S1A (RTA)
25	Spare
26	Spare
27	Spare
28	Spare
29	Spare
30	Spare
31	Spare
32	Spare
33	Spare
34	30 Hz Clock from RTA
35	Spare
36	Select 1 kHz Range from S1A (RTA)

Table 2-8. J15 Connector Functions

Pin	Function
1	WORD SYNC output from RTA
2	Select 20 kHz Range from S1A (RTA)
3	*Bit 1 (MSB) output from RTA
4	*Bit 2 output from RTA
5	*Bit 3 output from RTA
6	*Bit 4 output from RTA
7	Select 10 kHz Range from S1A (RTA)
8	Select 5 kHz Range from S1A (RTA)
9	*Bit 5 output from RTA
10	Select 2 kHz Range from S1A (RTA)
11	*Bit 6 output from RTA
12	*Bit 7 output from RTA
13	Select 50 kHz Range from S1A (RTA)
14	*Bit 8 output from RTA
15	*Bit 9 output from RTA
16	*Bit 10 output from RTA
17	FRAME SYNC output from RTA
18	Remote Freq Offset to RTA
19	Memory Period SYNC ENABLE to RTA
20	Ground
21	Spare
22	Spare
23	Spare
24	*Bit 11 output from RTA
25	*Bit 12 (LSB) output from RTA
26	LIN SPECTRUM SELECT to RTA
27	Spare
28	Spare
29	Spare
30	Spare
31	Spare
32	Spare
33	Spare
34	Spare
35	Spare
36	Select 1 kHz Range from S1A (RTA)

*This signal present only with a "-12B" modification.

Table 2-9. J30 Connector Functions

Pin	Function
1	2^0 } INPUT RANGE
2	2^1 } (Coarse) Select to RTA
3	2^2 } (10 dB steps)
4	2^0 } GAIN (Post
5	2^1 } Filter) Select to RTA
6	2^0 } ONES
7	2^1 } ONES
8	2^2 } ONES
9	2^3 } ONES
10	2^0 } TENS
11	2^1 } TENS
12	2^2 } TENS
13	2^3 } TENS
14	2^0 } HUNDREDS
15	2^1 } HUNDREDS
16	2^2 } HUNDREDS
17	2^3 } HUNDREDS
18	MANUAL MODE Select to RTA
19	TRANSIENT TRIGGER to RTA
20	SPECTRUM LIN STEP from RTA
21	FREQ LIN STEP from RTA
22	MARKER to RTA
23	RETRACE BLANKING from RTA
24	MEMORY SYNC from RTA
25	Spare
26	2^0 } INPUT RANGE
27	2^1 } (Fine) Select
28	2^2 } to RTA
29	2^3 } (1 dB steps)
30	2^0 } ANALYSIS RANGE
31	2^1 } ANALYSIS RANGE
32	2^2 } ANALYSIS RANGE
33	2^3 } ANALYSIS RANGE
34	Input OVERLOAD Sense from RTA
35	Output OVERLOAD Sense from RTA
36	"A" } Sense Strobe*
37	"B" } Sense Strobe*
38	"C" } Sense Strobe*
39	"D" } Sense Strobe*
40	2^0 } Sense Outputs
41	2^1 } Sense Outputs
42	2^2 } Sense Outputs
43	2^3 } Sense Outputs
44	Spare
45	Spare
46	Gnd
47	Gnd
48	Gnd
49	Gnd
50	Gnd

Strobe*	Parameter
"A"	INPUT RANGE (10 dB)
"B"	INPUT RANGE (1 dB)
"C"	GAIN
"D"	ANALYSIS RANGE

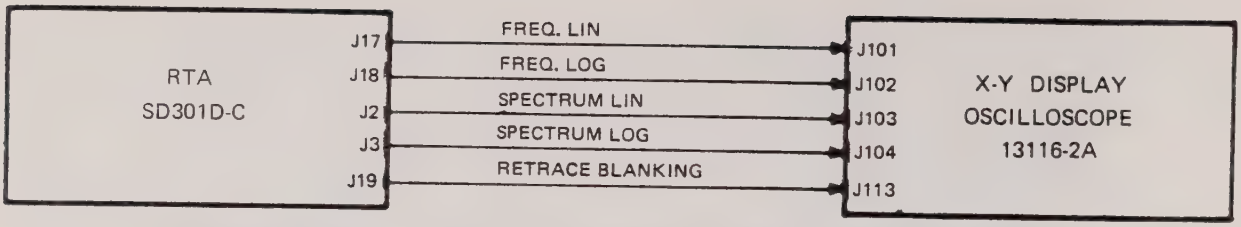


Figure 2-22. Setup for SD301D-C RTA and Model 13116-2A X-Y Display Oscilloscope

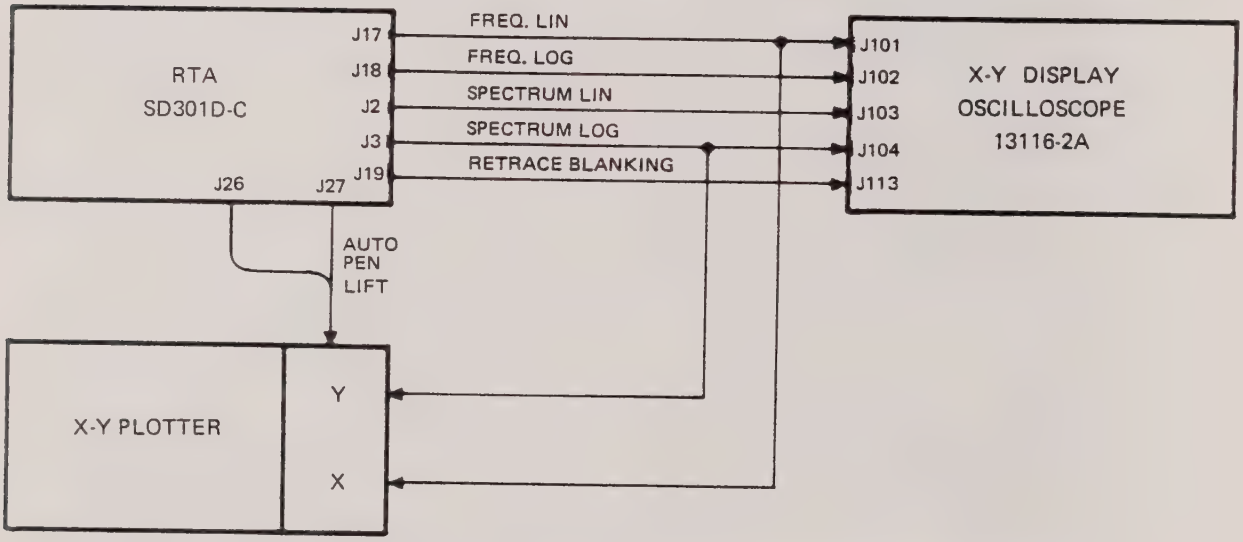


Figure 2-23. Setup for SD301D-C RTA, Model 13116-2A X-Y Display Oscilloscope and Plotter

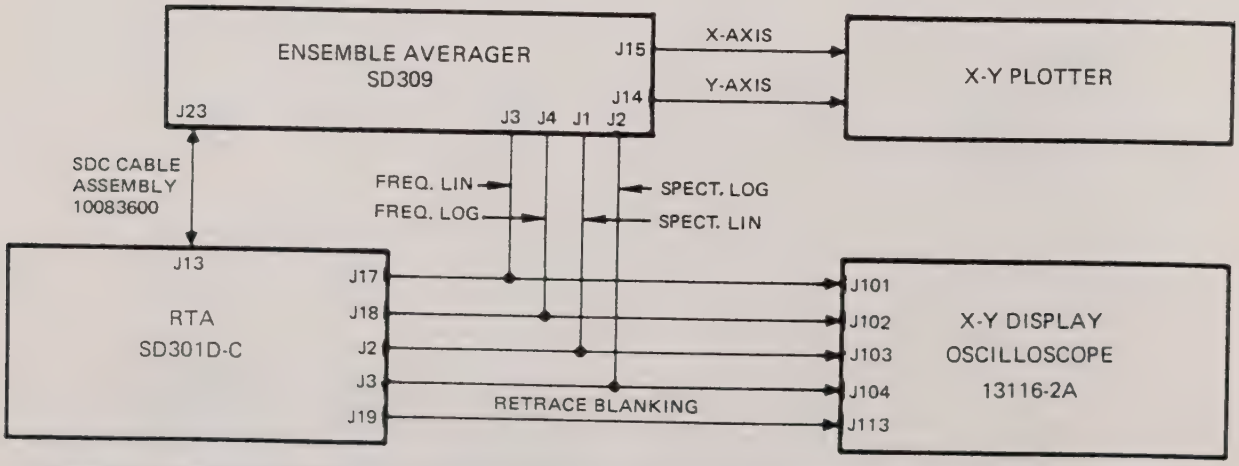


Figure 2-24. Setup for SD301D-C RTA, Model 13116-2A X-Y Display, X-Y Plotter and SD309 Ensemble Averager

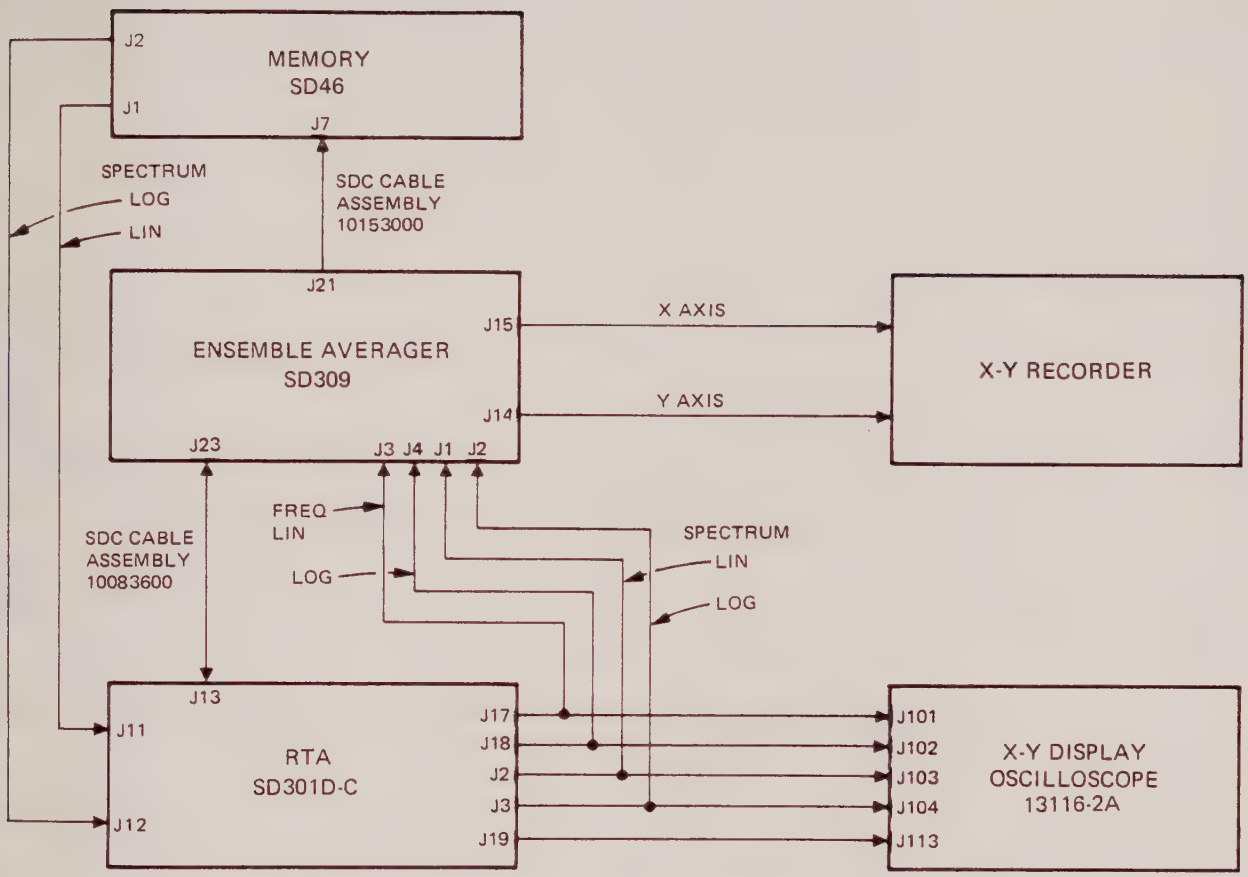


Figure 2-25. Interconnect Diagram- Averaging with Dual Memory

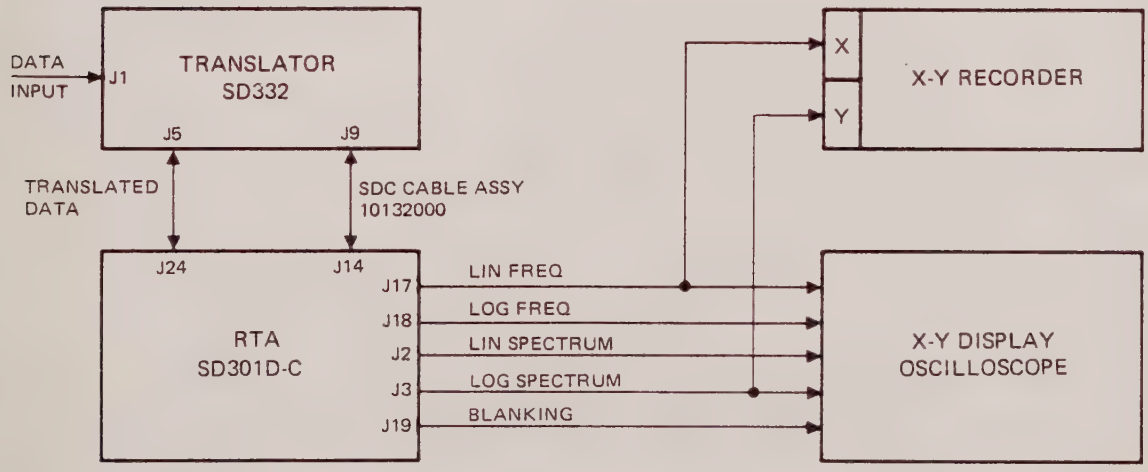


Figure 2-26. Interconnect Diagram-RTA with Translator

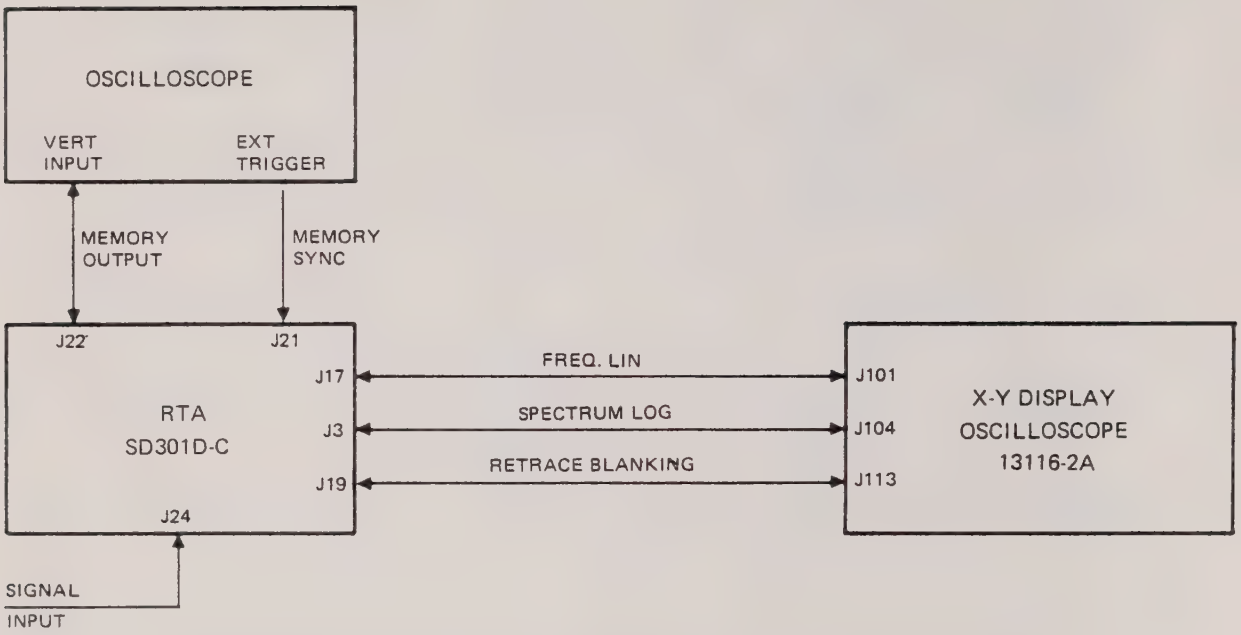


Figure 2-27. Interconnect Diagram-Viewing Memory Contents and Signal Spectrum

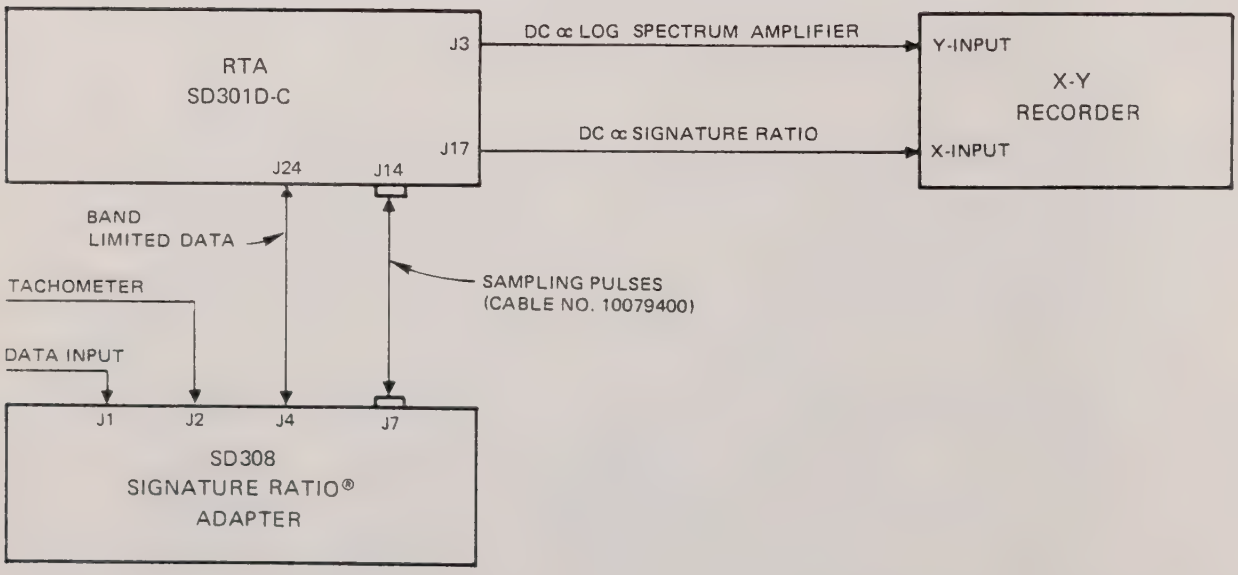


Figure 2-28. Interconnect Diagram-Signature Ratio ® Analysis

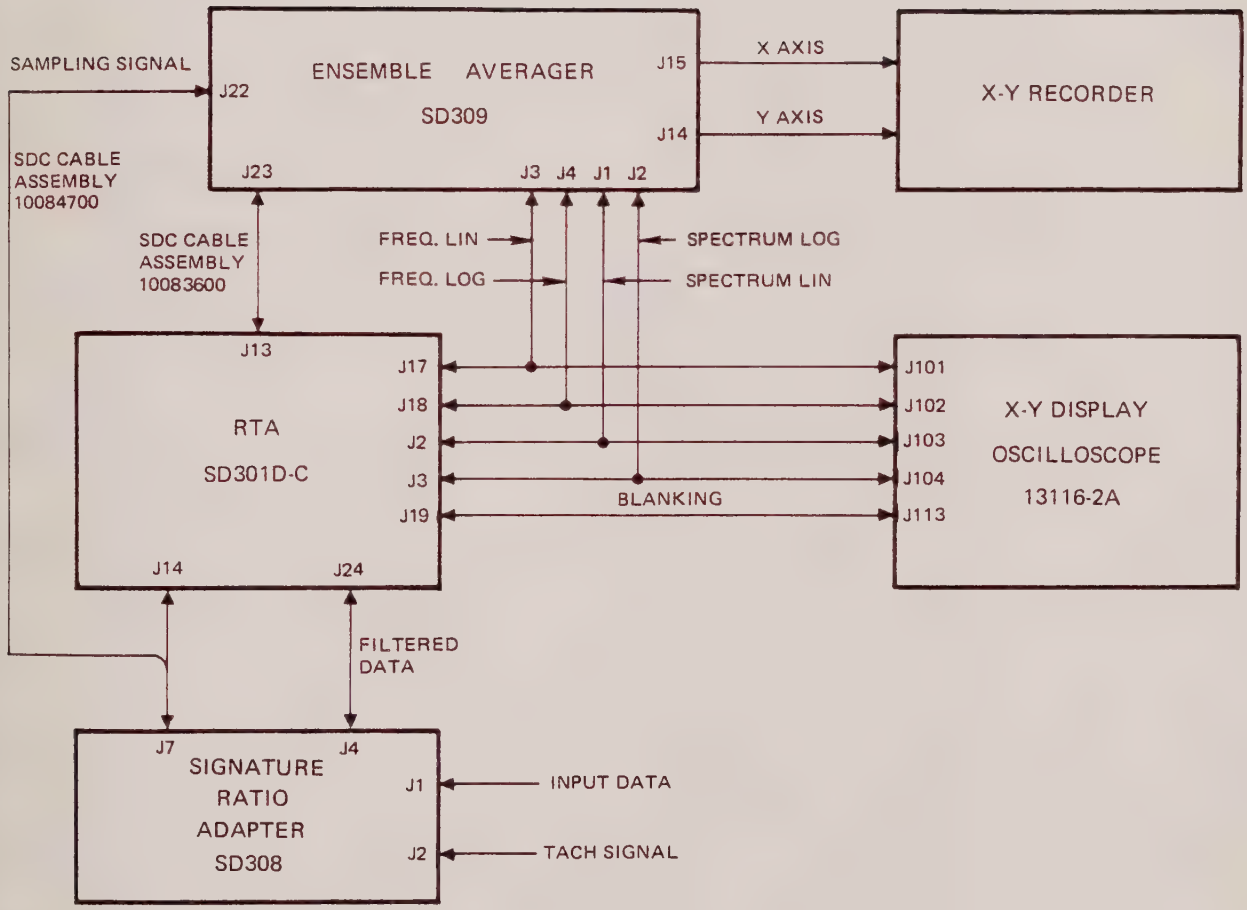


Figure 2-29. Interconnect Diagram -Averaging with Signature Ratio ® Analysis

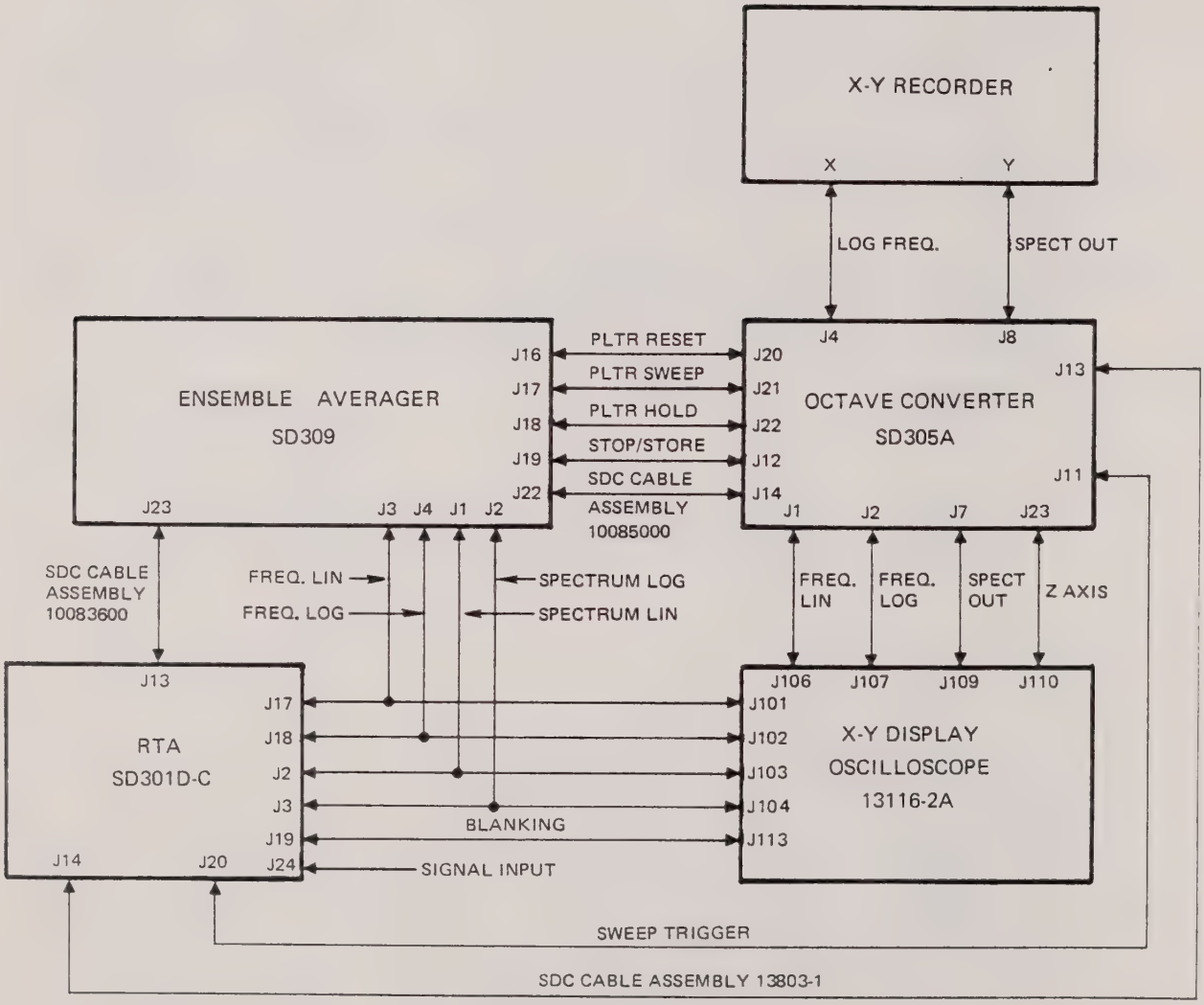


Figure 2-30. Interconnect Diagram-Octave Band Averaging

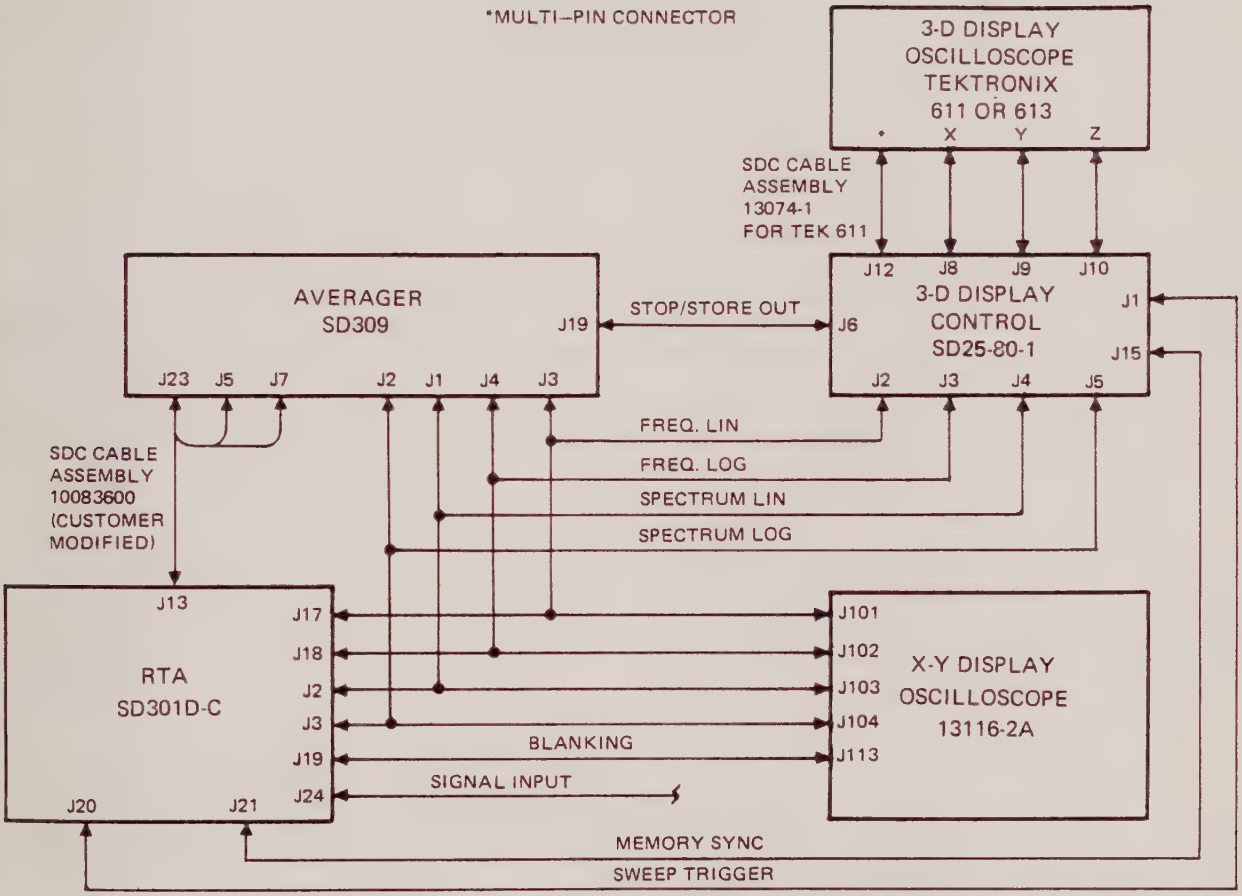


Figure 2-31. Interconnect Diagram for SD301D-C RTA, SD309 Ensemble Averager, SD25-80-1 3-D Display Control, Model 611 Tektronix Storage Oscilloscope, and the Model 13116-2A X-Y Display Oscilloscope

SECTION III

CONCEPT AND THEORY OF OPERATION

3.1 CONCEPT OF OPERATION

The Real Time Analyzer operates as a frequency-tuned bandpass filter to convert the input signal from the time domain to the frequency domain. Figure 3-1 is a Block Diagram of the Concept of Operation. Data enters the RTA through a buffer amplifier then goes to a lowpass aliasing filter where signals at twice the upper frequency limit are attenuated by at least 54 dB.

The signal is then digitized and applied through a digital buffer to a recirculating memory. The data is loaded at the digitizing rate (for signals above 10 kHz the multiple is a fraction) but always unloaded from the memory in the fixed time of 100 microseconds resulting in signal speedup.

Data is converted back to analog form as it exits from memory. This signal is heterodyned to the center frequency of the analyzer filter, weighting is added and filtering is accomplished. This is repeated 500 times for a complete analysis. The detector output represents the amplitude versus filter location of the input signal. This signal is applied to both linear and log amplifiers, is multiplexed for display on an oscilloscope, for an input to an X-Y plotter or for outputting to a data-processing device.

Frequency (X-Axis) and spectrum (Y-Axis) outputs are provided in linear step, linear smooth and log smooth form. An internal marker generator and calibrate signal facilitate oscilloscope and X-Y recorder calibration on all ranges. Time markers, sweep rate and operational modes can be controlled by application of external signals.

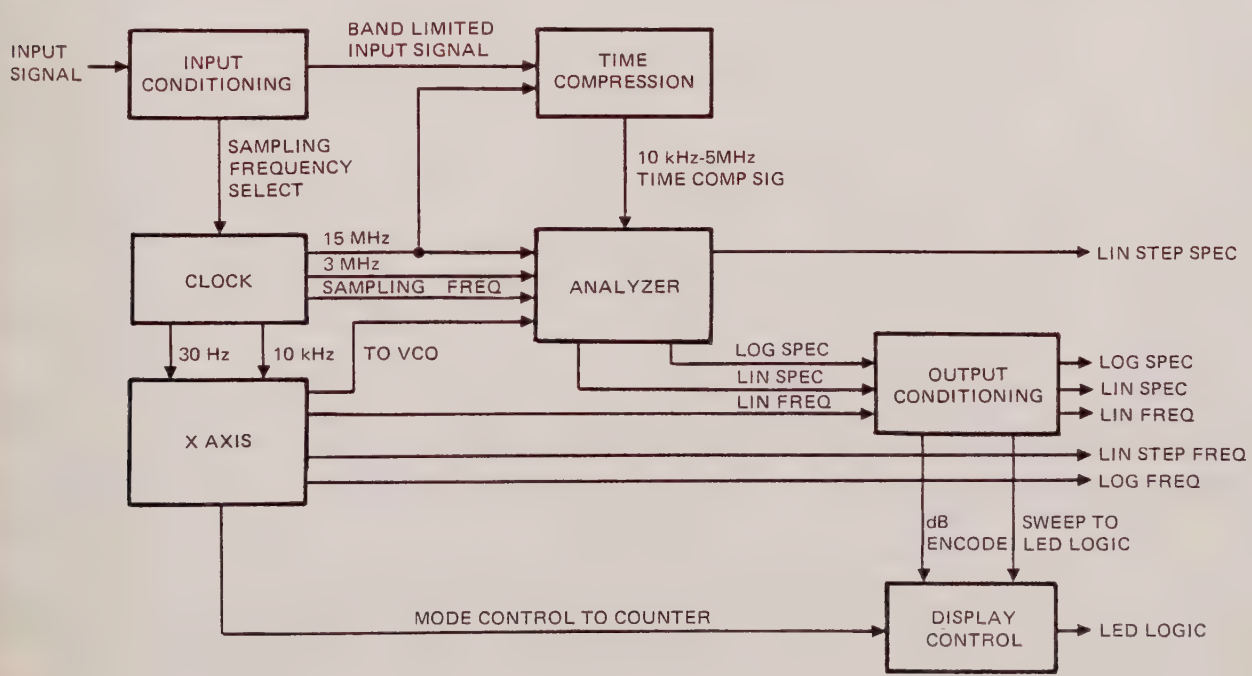


Figure 3-1. Concept of Operation

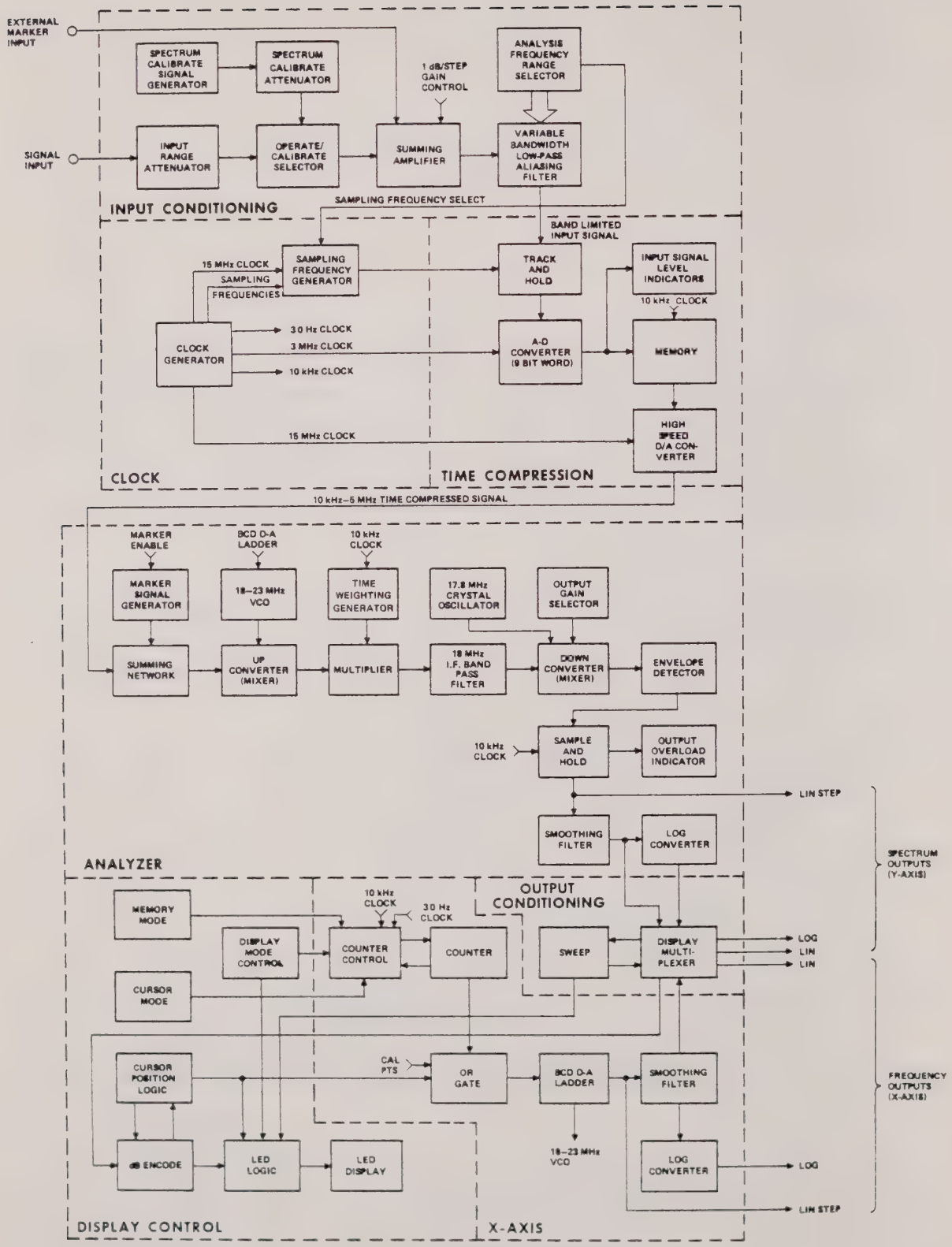


Figure 3-2. Block Diagram of the Real Time Analyzer

3.2 RTA THEORY OF OPERATION

Figure 3-2 is a simplified block diagram of the RTA theory of operation. Each section is a block in the Concept of Operation Diagram.

3.2.1 Input Conditioning (See Figure 3-3.)

The purpose of this circuitry is to provide a 5V p-p full-scale band-limited signal to the analog-to-digital (A-D) converter in the time-compression section. The input signal to be analyzed is routed to the INPUT RANGE (Vrms) control attenuators. In combination, a total of 49 dB attenuation is available in calibrated 1 dB steps; the coarse control provides 40 dB attenuation in 10 dB steps, and the fine control provides 9 dB attenuation in 1 dB steps. This control arrangement allows any input signal between 0.1 Vrms (minimum) and 28.2 Vrms (maximum) to be adjusted for full scale.

With the OPER/CAL control in the OPER position, the properly attenuated input signal is applied to input circuit card (A32). Here the signal is buffered and applied to the input of a variable-bandwidth low-pass aliasing filter. Also at this point, externally applied marker signals can be summed with the input signal via the FREQUENCY MARKERS control. With a 1 Vrms marker input signal, the output markers displayed are approximately –20 dB below full scale on any range.

The upper frequency limit, the filter bandwidth, and the memory period are simultaneously selected by the ANALYSIS RANGE selector. For example, in the 50-kHz ANALYSIS RANGE setting, the analyzer accepts input signals up to 50 kHz (UPPER LIMIT), the synthesized filter bandwidth is 150 Hz, and the time allotted for filling the memory is 0.01 second.

The actual bandwidth of the aliasing filter is always 1.1 times the bandwidth as selected by the front-panel ANALYSIS RANGE control. The band-limited signal is amplified and then routed to the time compression circuitry.

3.2.2 Time Compression (See Figure 3-4.)

The time-compression circuitry samples the conditioned band-limited input signal at the rate of three times the upper frequency limit of any selected ANALYSIS RANGE. Note that according to sampling theory, a signal can be completely reconstructed from at least two samples taken at twice the highest signal frequency. The samples are then converted to 9-bit binary digital words that correspond to signal amplitude at the time of the sample. These digital numbers are sensed by the INPUT signal level indicator circuit. This circuit provides a front-panel indication of the INPUT SIGNAL level. The 9-bit binary numbers are placed in the recirculating memory in such a manner that the time between samples

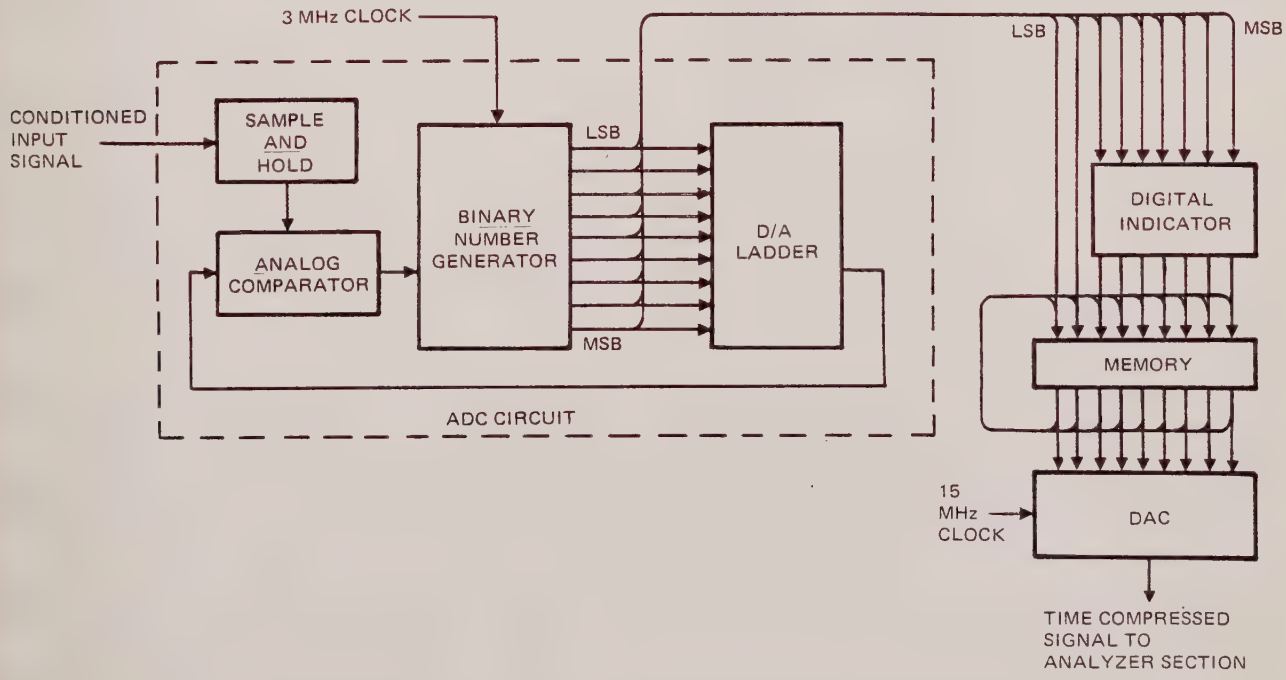


Figure 3-3. Block Diagram of Time Compression Section

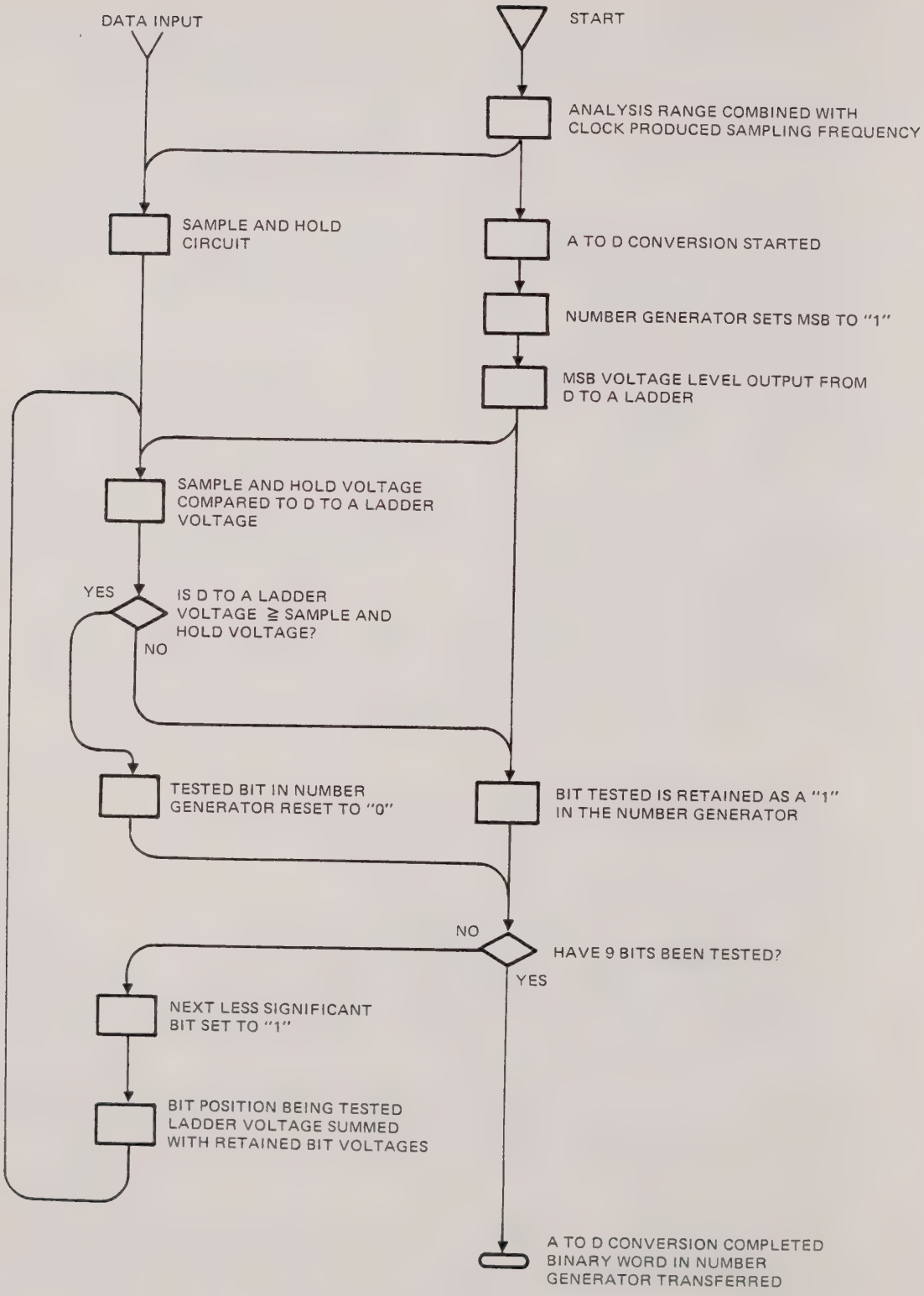

DATA INPUT
START
ANALYSIS RANGE COMBINED WITH CLOCK PRODUCED SAMPLING FREQUENCY
SAMPLE AND HOLD CIRCUIT
A TO D CONVERSION STARTED
NUMBER GENERATOR SETS MSB TO "1"
MSB VOLTAGE LEVEL OUTPUT FROM D TO A LADDER
SAMPLE AND HOLD VOLTAGE COMPARED TO D TO A LADDER VOLTAGE
YES
IS D TO A LADDER VOLTAGE ≧ SAMPLE AND HOLD VOLTAGE?
NO
TESTED BIT IN NUMBER GENERATOR RESET TO "0"
BIT TESTED IS RETAINED AS A "1" IN THE NUMBER GENERATOR
NO
HAVE 9 BITS BEEN TESTED?
YES
NEXT LESS SIGNIFICANT BIT SET TO "1"
BIT POSITION BEING TESTED LADDER VOLTAGE SUMMED WITH RETAINED BIT VOLTAGES
A TO D CONVERSION COMPLETED BINARY WORD IN NUMBER GENERATOR TRANSFERRED

Figure 3-4. A/D Conversion Process

is compressed, thus effectively increasing the frequency of the basic input signal. The output of the recirculating memory is transferred to a high-speed D/A (digital to analog) converter. The D/A converter reconstructs an analog signal whose waveshape is that of the original input signal, but whose frequency is from 100 (50-kHz range) to 500,000 (10-Hz range) times the original input frequency. This time-compressed signal is routed to the analyzer section.

Before sampling the conditioned input signal is applied to a buffer on card A13. The buffer provides a 5V p-p full-scale output that varies about a 2.5V fixed d-c bias. Shifting the 0V reference level to 2.5 Vdc automatically establishes the sign of the signal voltage in the subsequent A/D conversion.

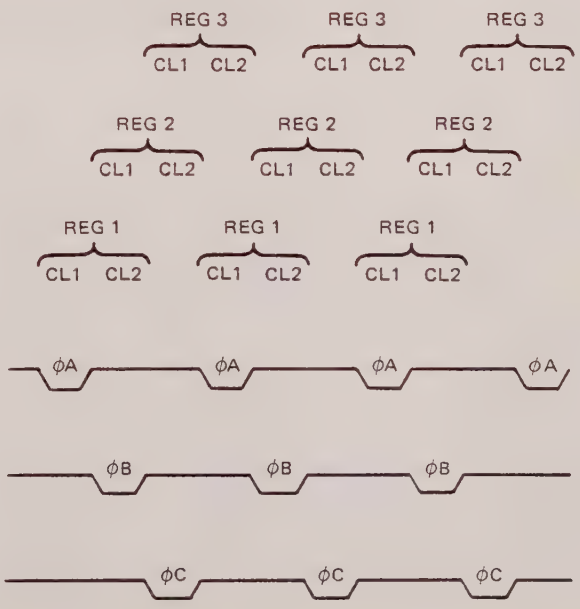
The conditioned input signal is converted from an analog form to digital form by means of the A/D converter (ADC) which works on a successive approximation process. Figure 3-3 contains a block diagram of the A/D converter circuit. The conversion circuits consist of a 9-bit binary number generator, a 9-bit D/A ladder, an analog comparator and a sample-and-hold. In this closed loop conversion process, the comparator compares each input voltage from the sample-and-hold circuit to the voltage output from the D/A ladder conversion of the number generator output. The analog comparator senses if the bit being tested causes the D/A ladder voltage level to exceed the input level, or is less than the input level, and directs the number generator to a smaller, or larger, next approximation.

The binary number generator starts the A/D conversion with all 9 bits "0." A "1" bit is successively tested in each of the 9 bit positions. Based on the output of the D/A ladder and the analog comparator, a binary number is constructed in the number generator such that when the number is converted back to an analog voltage level, it equals the input signal. The output of the number generator is the input to the D/A ladder and the input memory.

The D/A ladder assigns a specific voltage level to each of the 9 input digital bits. The most significant bit is assigned a voltage level of 2.5V. The next less significant bit is assigned a voltage level that is 1/2 the voltage level of the most significant bit, that is, 1.25V. Each succeeding less significant bit is assigned a voltage level 1/2 the voltage level of the next preceeding more significant bit. The least significant bit is assigned a voltage level of 9.7 mV (nominal). A "1" in a bit position causes the corresponding assigned voltage level to be active; a "0" blocks the voltage level. A sum of all active voltage levels produces the analog voltage level corresponding to the input binary number. The output of the D/A ladder is the input to the analog comparator. When the bit being tested causes the D/A ladder voltage level to exceed the input voltage level, the analog comparator outputs a reset pulse to the number generator and the bit being tested is reset to "0." See Figure 3-4 for a D/A conversion process. This process continues until 9 bits have been tested. Each sample of the analog signal is converted by this process into a 9-bit word which is parallel transferred into the memory under the control of the clock.

Each bit is transferred in parallel into a circulating register memory (A3-A11). The 9 memory registers for the 9 bits operate identically; therefore, operation for only one bit is described.

See the block diagram of Figure 3-5. The memory comprises three 500-bit MOS shift registers. For purposes of discussion, they have been numbered: 1, 2, and 3, in Figure 3-5. The memory is continuously loaded and unloaded at a bit-rate of 15 MHz; however, each individual shift register is operated at only 5 MHz. This is accomplished by dividing the 15-MHz clock into 3-phase 5 MHz; that is, assigning "ϕA" to any 15-MHz shift pulse, the following shift register clocking pulses would be in succession, ϕB, ϕC, ϕA, ϕB, ϕC, etc. In this way, the three shift registers (See below) are sequentially loaded and unloaded for outputting and recirculation in the order: No. 1, 2, 3, 1, 2, 3, etc., at an individual bit-rate of 5 MHz, and at an overall bit-rate (for the 3-register combination) of 15 MHz.



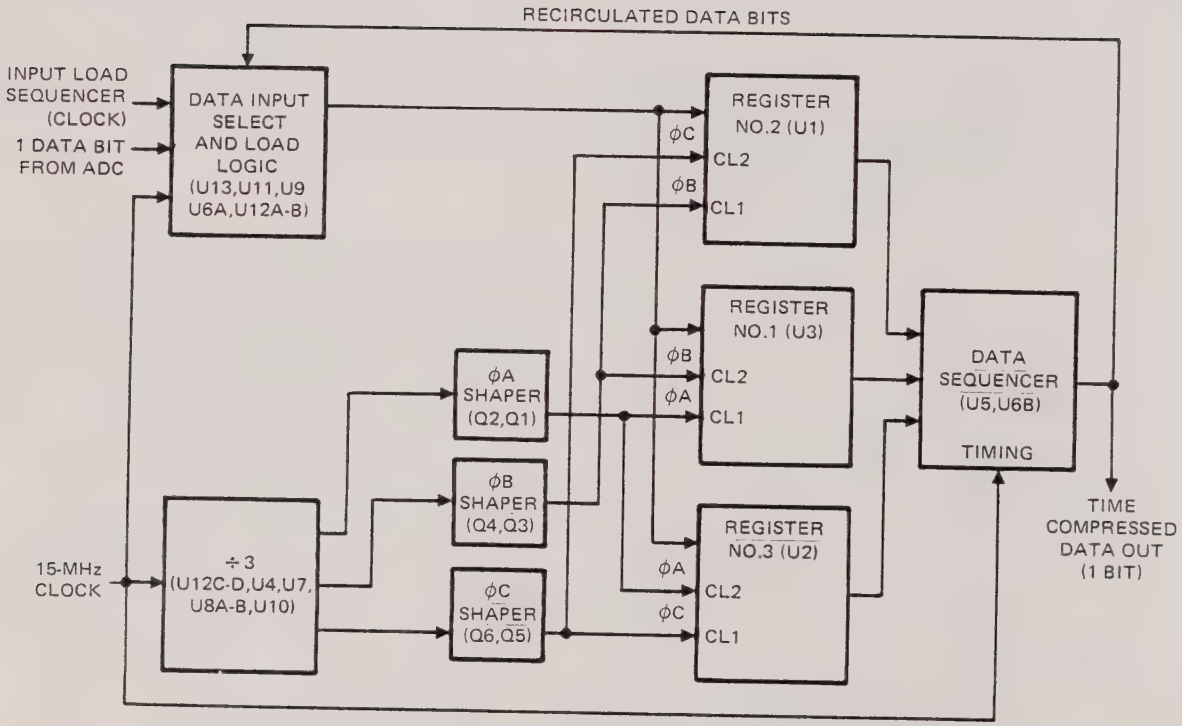


Figure 3-5. Block Diagram of Shift Register Memory for 1 Bit

Although the memory operation involves three 500-bit shift registers that are sequentially shifted, for sake of clarity, the following description of time compression treats the total 1500 bit spaces of the memory as being in one continuous series.

To illustrate a typical example of time compression, assume operation in the 50 Hz RANGE. The sampling rate is 150 samples per second; that is, a sample is taken and digitized every 6.667 milliseconds. The first bit is applied, travels through the registers and is recirculated (fed back to the input again). The first bit recirculates 66 times; this requires 6,600 microseconds. The first bit travels two-thirds of the path again (for the 67th time) when the second bit is available. To load the second bit immediately after the first bit (by 67 nanoseconds), the second bit is temporarily stored until the first bit emerges from the registers. The first bit is then re-entered, and then the second bit is applied 67 nanoseconds behind the first bit.

Now these two bits recirculate and are joined by a third, fourth, fifth, etc. bit, each 67 nanoseconds apart, until over a period of 10 seconds, 1500 bits have been entered and are circulating. The time compression just described compresses an interval of 6.667 milliseconds between data samples to an interval of 67 nanoseconds between output data points, or a time compression ratio of 100,000 to 1.

Note that the time interval between the digitized samples in the memory is only a fraction of the time interval between samples of the analog input signal. In this example, the data samples taken at 150 samples per second are digitized and compressed into the memory at 15 million bits per second. Thus a speed-up ratio of 100,000 is realized. Or in other words, by contracting the input signal's time base, a 50-Hz input signal is speeded up to 5 MHz.

The benefit realized from time compression (speeding up of the input signal frequency before analysis) is that the 50-Hz input of the previous example speeded up to 5 MHz can now be analyzed with an equivalent resolution in a fraction of the time. This permits processing the signal at a much faster rate; thus the input spectrum is scanned very fast making possible a real time analysis.

The memory output of 9 data bits is parallel transferred to a high-speed digital-to-analog converter (DAC). The D/A converter (A1) accepts the digital words at the 15-MHz clock rate and produces a "box car" type of a waveform representation of the data samples in memory.

The output of the high-speed DAC, a time-compressed replica of the input signal, is routed to the analyzer section.

3.2.3 Analyzer (See Figure 3-6.)

The analyzer section scans the 10-kHz to 5-MHz time-compressed signal by mixing it with an 18-MHz to 23-MHz swept tuning signal that is incremented in 500 10-kHz intervals or 1000 5-kHz intervals. Because the data record in memory is 100 microseconds long, a single 10-kHz bandpass filter (18 MHz center frequency) can analyze the entire spectrum by responding successively to the adjacent 10-kHz segments of frequency components. This technique provides 500 synthesized 10-kHz filter locations.

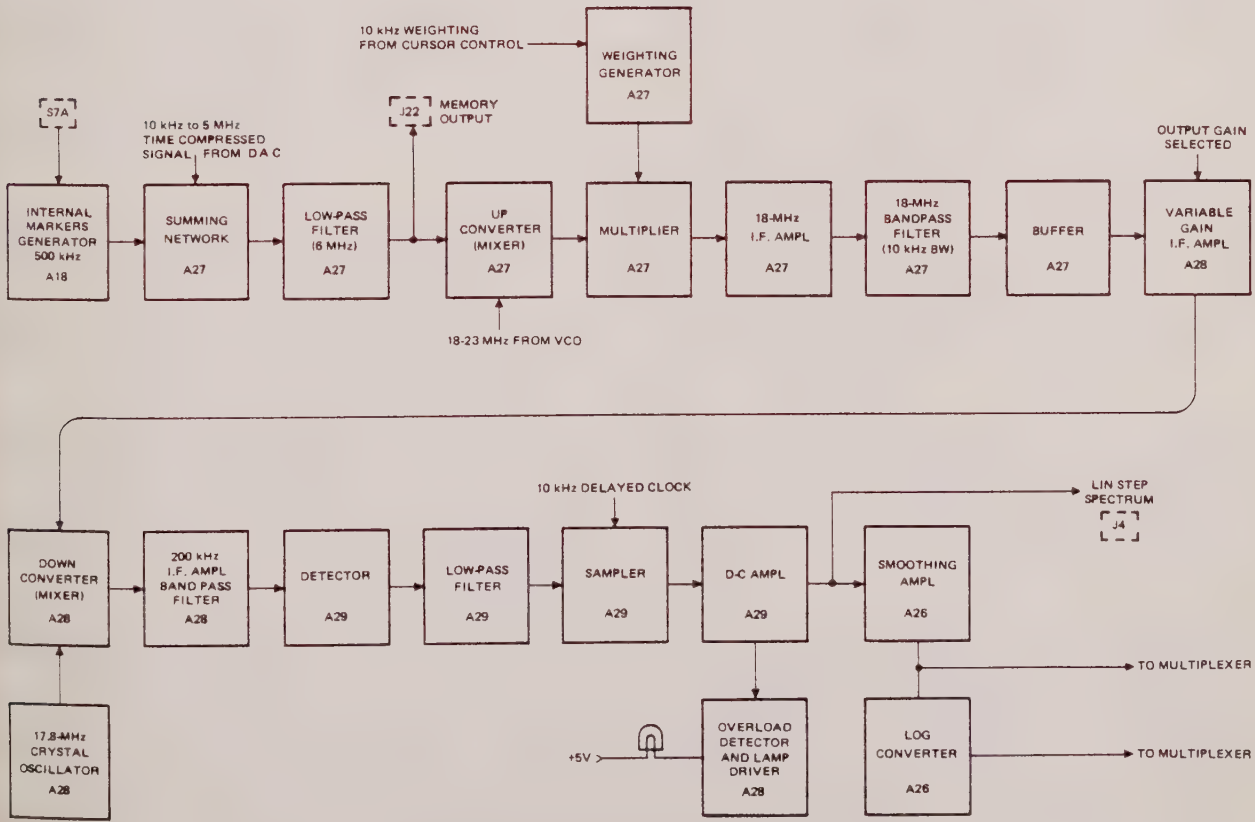


Figure 3-6. Analyzer Block Diagram

After filtering, the 18-MHz I.F. signal is down-converted to 200 kHz and then detected to provide the LIN STEP, LIN, and LOG SPECTRUM OUTPUTS.

The time-compressed signal is applied to a summing network at the input of the scan unit (A27). If the front-panel FREQUENCY MARKERS contol is set to INT, an internally generated 500-kHz pulse signal from marker generator A18 is linearly combined with the time-compressed signal. The 500-kHz output pulse train, when summed with the time-compressed signal, produces 10 equally spaced frequency marker "pips."

The output of the summing network is passed through a low-pass filter. This filter has a very high stop-band rejection and thereby passes only the 10-kHz to 5-MHz speeded-up data. The filtered signal is available at MEMORY OUTPUT connector J22; it is also applied to the up-converter (mixer).

The up-converter, a balanced modulator, combines the filtered analog time-compressed signal (and internal markers, if added) with the 18-MHz to 23-MHz tuning signal from the VCO. The balanced modulator leaves only the upper and lower sidebands; the lower sideband is used for its information content.

The up-converted 18-MHz I.F. signal output is combined in a multiplier circuit with a 10-kHz weighting signal. The 18-MHz signal is caused to vary in amplitude from zero to maximum at a 10-kHz rate. This technique, called time-weighting, modifies the shape of the filter output response without changing the signal's center frequency, and effectively eliminates the spectra produced by truncation due to a finite record length in the memory.

Another benefit of time weighting is the improved selectivity of the narrow-band analyzing filter. This filter consists of a crystal resonator (at 18 MHz) having a single-degree-of-freedom response; that is, its response is that of a single-tuned circuit.

The time weighting modifies the spectrum of the narrow-band signal such that the filter asymptotic response has an attenuation improvement from 6 dB per octave to 24 dB per octave, and the center passband is about 1-1/2 times wider between the 3 dB bandwidth points. In this way the selectivity is improved without the use of a narrower band filter which would decrease the analysis rate. This improved response time makes possible real time analysis.

The 18-MHz filtered I.F. signal is buffered and routed to the down-converter (A28).

Preceding the down-converter mixer circuit, a variable gain amplifier provides fixed gains of 1, 3.16, 10, or 20 as selected by the front-panel OUTPUT GAIN control. For all normal levels of periodic input signals, the GAIN control should be set to 1 (0 dB). When analyzing a random type signal input such as white noise, because of the low energy content in the narrow-band samples taken from such a broad spectrum, additional gain can be inserted as required for a suitable output presentation.

The 18-MHz signal is mixed with a 18.7-MHz signal from a crystal-controlled oscillator. The 200-kHz difference frequency signal is selected by a 200-kHz bandpass filter. The bandwidth is approximately 175 kHz about the 200-kHz center frequency. The 200-kHz signal is buffered and fed to the detector card, A29.

A linear envelope detector is used to demodulate the 200-kHz I.F. signal. The detected signal is filtered to remove the 200-kHz carrier, and then sampled. Sampling is accomplished by passing the detected signal through a gate that is controlled by the 10-kHz clock signal. Thus, a sample is taken every 100 microseconds in synchronism with the time weighting function. Note that the d-c value (0 to 5V) of each step is proportional to the sampled spectrum signal amplitude of the synthesized filter location.

The samples are amplified and routed to the output overload detector on A28, to the SPECTRUM LIN STEP output connector J1 on the rear chassis, and to the RTA output amplifier, A26. The overload detector is adjusted to cause the front-panel OUTPUT OVERLOAD indicator to flash if the level of the d-c samples exceeds 5V.

The d-c samples from the detector are routed to a d-c smoothing amplifier on A26 which provides a 0 to 5V signal. This signal in turn drives a log converter, located on the same card, which produces a 0 to 1V output that is proportional to the log of the RTA spectrum. A jumper selected signal, normally selecting the log output, is routed to RTA SPECTRUM (J4). The smoothed output and log output are also routed to a multiplexer card where they provide one possible choice of SPECTRUM LIN (J2) and SPECTRUM LOG (J3). An optional output amplifier assembly (NO. 11430-3) located on A21 is available to provide a d-c output equal to the square of the RTA spectrum. The LIN STEP signal at J30-20 is selected by a relay, located on A21, which chooses either the RTA spectrum or the spectrum from an external averager.

3.2.4 Output Conditioning

The RTA spectrum from the Detector can be selected by electronic switches which comprise the display multiplexer as shown in Figure 3-7.

3.2.4.1 Spectrum Display Multiplexer (A24) (See Figure 3-7.)

The DISPLAY MODE control determines which spectral output signals are selected by the multiplexer input/output switches, which are MOS transistors. In any direct mode (RTA FAST, RTA SLOW, AVG, and STORED AVG PLOTTER) the output E is selected.

In any of the chopped modes, CHOP ϕ_1 and CHOP ϕ_2 are alternately selected at a 40 kHz rate. A separation voltage is added to CHOP ϕ_2, which is always the second signal indicated on the DISPLAY MODE, by the SEPARATION control to permit better comparison of signals.

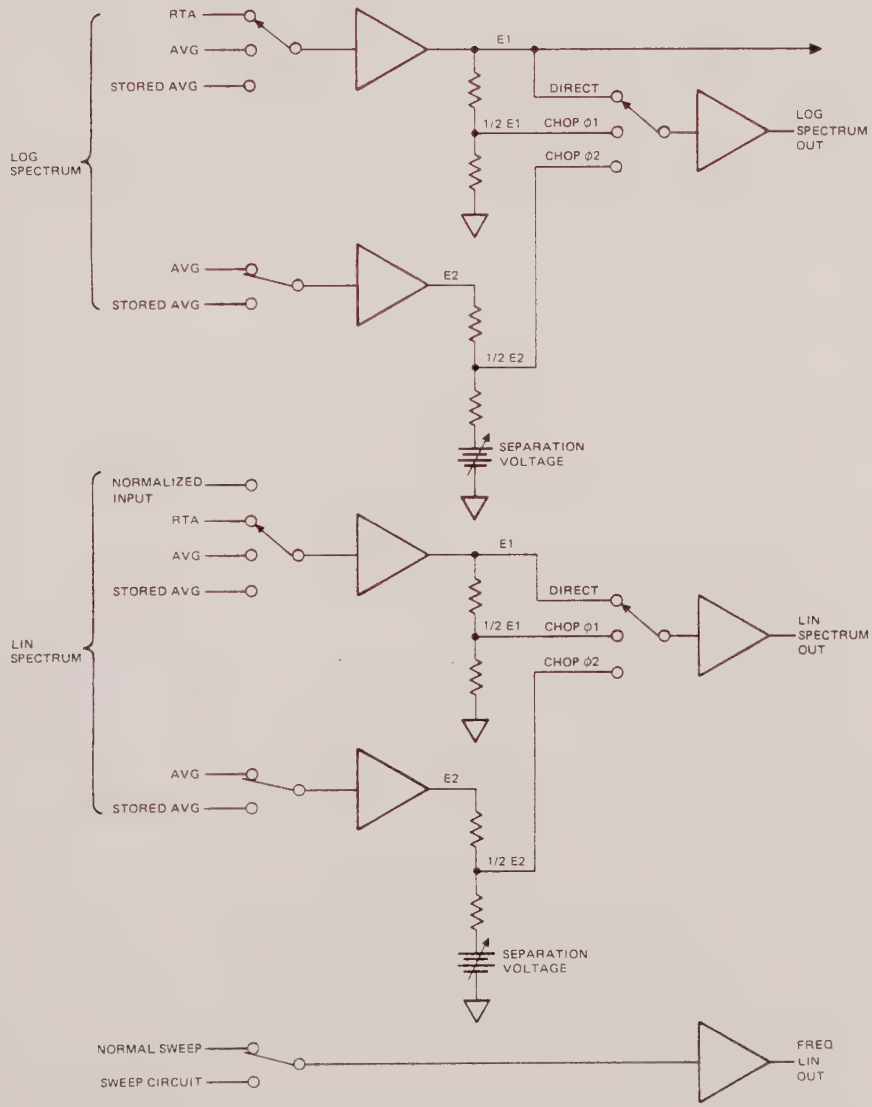


Figure 3-7. Display Multiplexer Block Diagram

3.2.4.2 Input Display (A22) (See Figure 3-8.)

The input signal is selected in the SIGNAL display mode. The input signal, after the input attenuator and preamplifier, but before the aliasing filter, can be viewed at the LIN SPECTRUM output connector, J2. In the SIGNAL display mode the normal 50 ms sweep is replaced by the output of the sweep circuit, shown in Figure 3-8. The Sweep Circuit generates a 0 to 5V ramp with the ramp time selected to display ten cycles of a full scale analysis range.

The Sweep circuit functions in the following manner. The normalized input signal zero crossing is amplified by the limiter and sets the flip flop, which opens the integrator feedback capacitor shorting switch and the integrator slews positive with the digital current source and the selected capacitor determining the slew rate. The digital current source and the selected capacitor are determined by the analysis range through the action of the range encoding logic.

When the integrator output reaches +5 volts, the comparator changes state firing a mono which resets the input flip flop. The capacitor shorting switch is held closed for at least the mono time. The circuit is now reset, waiting for the next signal zero crossing.

3.2.5 18–23 MHz VCO (See Figure 3-9)

The Voltage-Controlled Oscillator (VCO) section generates an 18- to 23-MHz signal, linearly stepped in 500 to 1000 increments, for use in the analyzer section. During a spectrum scan, the 10-kHz clock signal drives a stepped-ramp generator that produces 500 or 1000 incremental voltage steps from 0V to 5V. The voltage steps are applied to the voltage-controlled oscillator (VCO) causing its output frequency to be stepped from 18–23 MHz. The VCO frequency is routed to the up converter (mixer) in the scan unit of the analyzer section. See the upper portion of Figure 3-9. The 18–23 MHz VCO consists of a voltage-controlled variable frequency LC oscillator, a charge-dump FVC (frequency-to-voltage converter), a constant-area FVC, a divide-by-16 counter, a divide-by-100 counter, and 2 operational amplifiers.

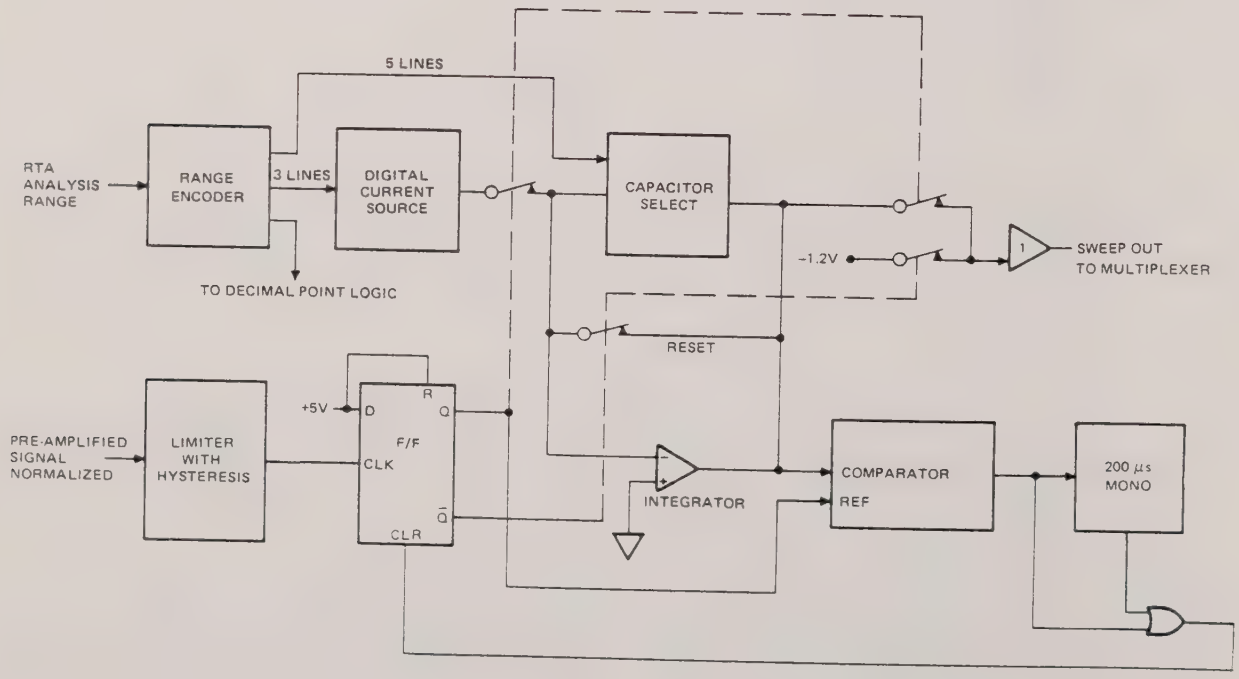


Figure 3-8. Sweep Circuit Block Diagram

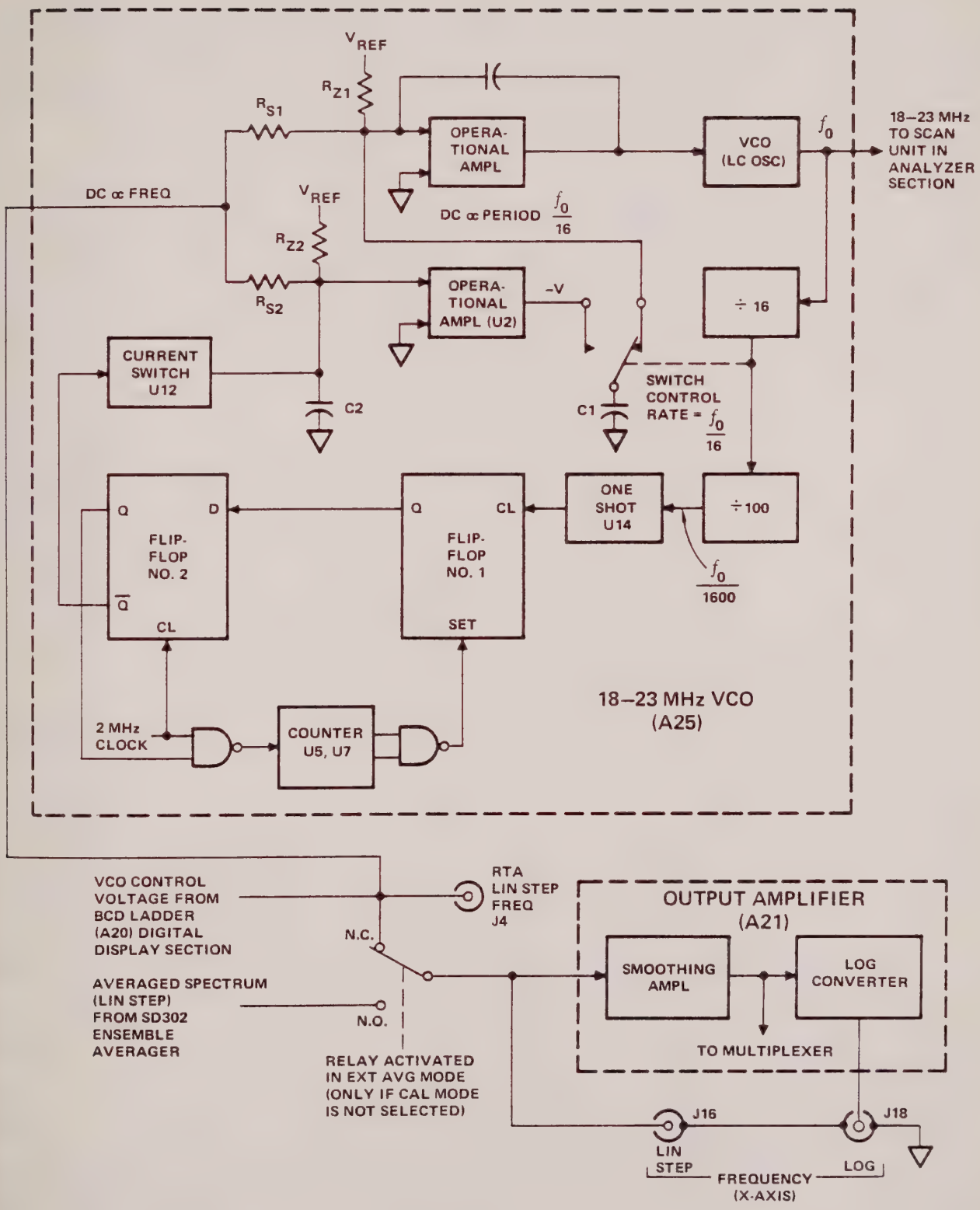


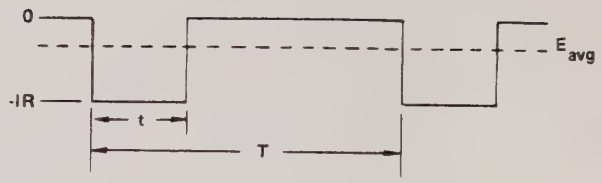
Figure 3-9. Functional Block Diagram of VCO

portion of Figure 3-9. The 18–23 MHz VCO consists of a voltage-controlled variable frequency LC oscillator, a charge-dump FVC (frequency-to-voltage converter), a constant-area FVC, a divide-by-16 counter, a divide-by-100 counter, and 2 operational amplifiers.

A voltage-variable capacitor is the frequency controlling element of the LC oscillator. As the 500 or 1000 voltage steps (increasing in value from 0V to 5V) from the BCD ladder are applied to the VCO, the output frequency is incremented from 18 to 23 MHz. This signal is divided by 16 to provide 1.125 to 1.438 MHz which is applied to the charge-dump FVC. The purpose of the charge-dump FVC is to linearize the frequency-versus-control-voltage-input characteristics of the LC oscillator.

In Figure 3-9, the charge-dump FVC is depicted functionally as a single-pole double-throw electronic switch. The switching rate is controlled by the output frequency (divided by 16) of the LC oscillator. The action of the switch alternately charges capacitor C1 to the voltage (–V) and discharges it into the summing junction at the input of the operational amplifier that precedes the VCO. Because the charge in C1 is transferred once each period of the divided-down VCO output frequency, the net current flow is proportional to the VCO output frequency. The operational amplifier compares this current with the net current flowing through R_{S1} and R_{Z1}, and drives the LC oscillator to a frequency which causes these currents to balance.

The purpose of the constant area FVC is to compensate for any frequency drift in the charge-dump FVC (normally due to temperature changes). The constant area FVC is not affected by temperature variations because it derives its conversion from the 2 MHz crystal controlled clock pulses and a Zener reference diode voltage source. The constant-area FVC comprises the circuitry in the lower portion of the 18–23 MHz VCO; i.e., the divide-by-100, one-shot (U14), flip-flops 1 and 2, counter (U5, U7), etc. The constant-area FVC performs frequency to voltage conversion by generating a current pulse of constant ampere-second area, once each cycle of its input frequency. This current pulse is filtered by capacitor C2 and passed through a resistor (equivalent to the parallel value of R_{S2} and R_{Z2}) to generate a voltage proportional to frequency. As shown in the waveform below, a negative pulse of amplitude –IR and width t occurs once each input period T (T equals the VCO frequency period times 1600). The average output voltage $E_{avg} = -IR(t/T) = -IRtf_0$; hence, the average voltage output is proportional to the input frequency.



The constant area pulse is generated by counting 90 2-MHz clock pulses. The divided-down VCO output frequency, $f_0/1600$, triggers one-shot U14 which in turn resets F–F No. 1. The "Q" output of F–F No. 1 raises the "D-line" input of F–F No. 2, allowing it be set by the next 2-MHz clock pulse. With F–F No. 2 set, its "Q" output enables the NAND gate at the counter input to pass 2-MHz clock pulses.

After 90 clock pulses are counted, an output from the counter sets F–F No. 1. This action lowers the "D-line" input to F–F No. 2, allowing it to be reset by the next 2-MHz clock pulse. The "$\overline{Q}$" output of F–F No. 2 turns on the current switch, U12. The output of the current switch is compared with the net current flowing through R_{S2} and R_{Z2} (see Figure 3-9) at the input of operational amplifier U2. U2 amplifies any difference by 100,000and produces an output of –5V. This voltage is further amplified to provide the charge voltage for the dump charge FVC.

The VCO control voltage steps are routed in all modes to rear-chassis connector J16, LIN STEP FREQ and to the frequency channel (X-Axis) on the output amplifier card (A21). (See the lower portion of Figure 3-9.)

Here a smoothing amplifier (A21) provides the FREQUENCY LIN output (0 to 5V) to the multiplexer and a log converter provides a 1V d-c FREQUENCY LOG output that is proportional to the log of the FREQUENCY LIN output. The LIN and LOG outputs are available at both front-panel and rear-chassis connectors for application to the X-axis of external recording equipment.

3.2.6 Display Control and X-Axis (See Figure 3-10.)

3.2.6.1 Display Control Logic

The Display control section performs various functions as selected by the front-panel controls and is controlled by either internally or externally applied control signals. The control functions are generated by the selected gating logic, which, in turn, operate as electronic switches or latches to pass or hold control levels and/or signals to applicable circuits in the various sections of the

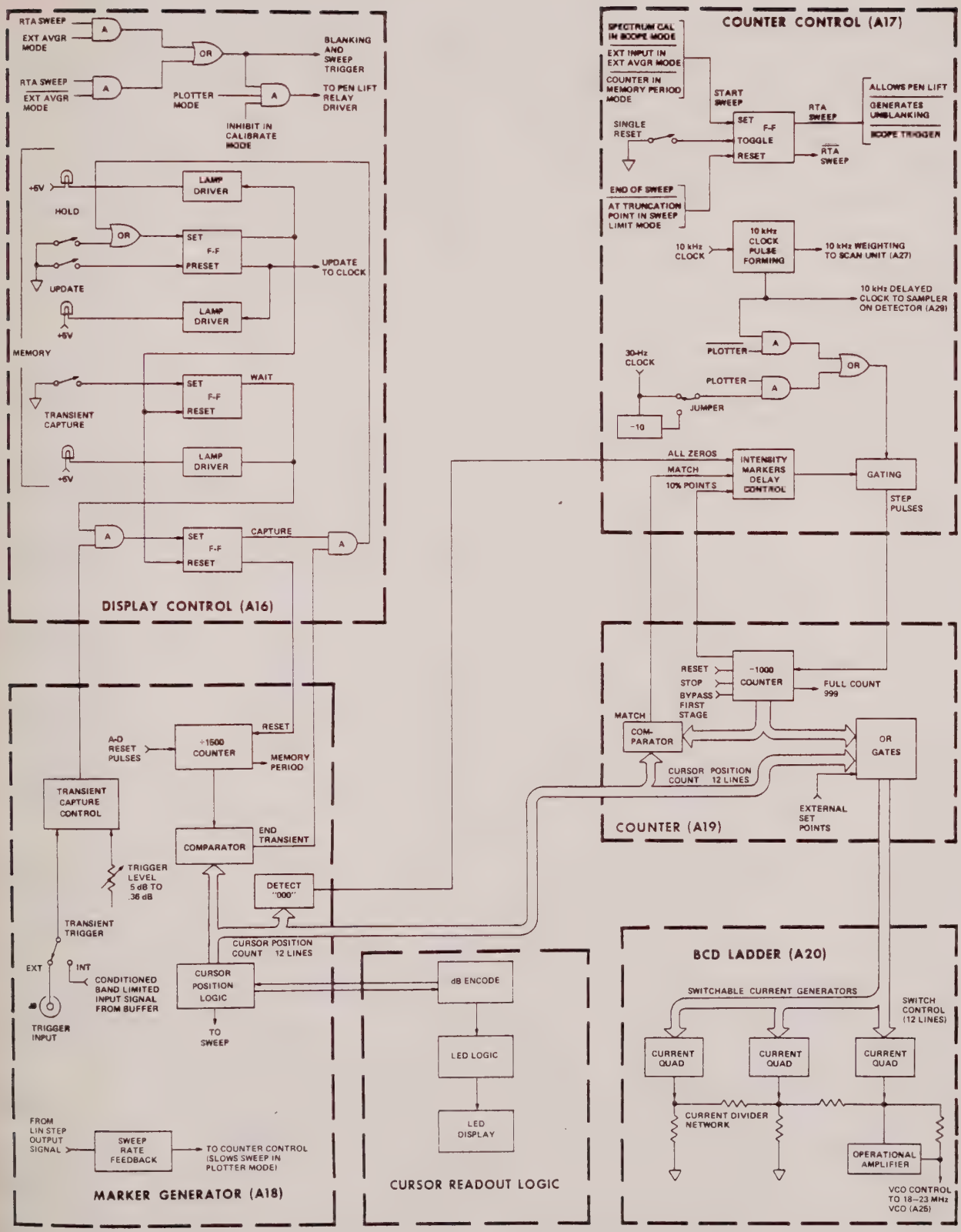


Figure 3-10. Display Control and X-Axis Block Diagram

instrument. The use of gating logic facilitates application of external control signals (normally a 5V pulse) to perform the same function as the front-panel controls.

The Display control section comprises the following circuit cards: display control (A16), marker generator (A18), Cursor position logic (A23), dB encode (portion of A24), and numeric indicator (A37).

The display control card (A16) contains three flip-flops that determine the MEMORY modes of operation: HOLD, UPDATE, and TRANSIENT CAPTURE. The two states of the first flip-flop are HOLD and UPDATE. The states of the other two flip-flops are: in transient capture mode, WAIT and CAPTURE; when not in transient capture mode, the flip-flops are reset. The output of the first flip-flop is the "clock update" signal; this signal determines whether or not data is loaded. When transient capture mode is initiated, the "wait" flip-flop is set; this output enables a gate at the set input to the "capture" flip-flop. When a transient trigger triggers this gate, the "capture" flip-flop is set and a transient capture cycle is initiated; this cycle is terminated automatically when the "hold" flip-flop is set. For example, the MEMORY TRANSIENT CAPTURE mode is manually activated by pressing the front-panel TRANSIENT CAPTURE push button. Then, with the TRANSIENT TRIGGER control set to INT (see card A18), transient capture is initiated as a function of the level of the conditioned band-limited input signal from the buffer (on card A32). In EXT mode, transient capture can be initiated by application of a trigger pulse (1V at 2 microseconds duration) applied to TRIG INPUT connector J9 on the rear chassis. Note that if the front-panel CURSOR MODE control is not set to TRANSIENT CAPTURE, the transient capture mode loads 1500 data points into the memory. If the control is set to TRANSIENT CAPTURE, the number of samples to be loaded is determined by the setting of the Cursor position control. (See marker generator card A18 on Figure 3-10.) The comparator senses when the count matches the number in the Cursor position setting and sends an "end transient" pulse to the display control card to activate the hold mode.

The internally generated frequency markers are supplied by marker generator card A18; this portion of the card is shown in Figure 3-6. Also on circuit card A18 is the sweep rate feedback control circuitry; it senses the SPECTRUM LIN STEP output, and if a large variation occurs in amplitude, the circuit develops a logic level that slows the sweep (PLOTTER MODE only).

The X-axis section consists of the Counter Control (A17), Counter (A19), BCD Ladder (A20) and the previously described portion of RTA Amplifier (A21).

The counter control card (A17) provides the sweep start/stop signal which allows pen lift, generates unblanking (output at J19), and supplies an oscilloscope trigger (output at J20). (The pen lift, unblanking, and scope trigger output driver circuits are on circuit card A16.) These outputs are generated as a function of the start-sweep signal applied to the "RTA flip-flop" set input. The end-of-sweep is generated at the truncation point in the sweep limit mode. The SINGLE RESET push button toggles the flip-flop thereby starting the sweep from a reset condition, or stopping the sweep if it is sweeping. Also on the counter control card is the 10-kHz inverter circuit that feeds the 10-kHz weighting circuit in the scan unit (A27).

As in the previously described time compression and analyzer sections, the overall operation of the 18-23 MHz VCO oscillator section is also synchronized to the internal clock frequencies. (See circuit card A17 in Figure 3-10.) The 10-kHz clock (or the 30-Hz clock in PLOTTER MODE) is gated through as step pulses under control of the intensity markers delay control logic. When the CURSOR MODE is set to INTENSIFY, an intensity marker is present when the ÷ 1000 counter matches the value of the Cursor Position count setting, except when this count is set to all zeroes (000). Then the 10% points are intensified. The ÷ 1000 counter is located on counter circuit card A19. It counts the 10-kHz step pulses. Its output (in binary coded decimal format) is gated through an OR gate and converted to a proportional analog voltage by BCD ladder card (A20). This d-c voltage is fed to the 18–23 MHz VCO (A25) for use as the VCO frequency control voltage. It is also routed to the smoothing amp and log converter of the output amplifier as previously described in Section 3.2.5 18-23 MHz VCO and X-Axis.

3.2.6.2 Cursor Position Logic (A23)

The Cursor generates a 3 digit BCD number by accumulating counts in an up/down BCD counter, which counts up when the CURSOR control is pushed to the right and down when it is pushed to the left. Figure 3-11 shows a block diagram of the Cursor Position Counter. The Cursor Position Count is not displayed directly, but is first multiplied by a constant determined by the analysis range, so that the display will read directly in hertz.

3.2.6.3 Frequency Readout

Multiplication by the analysis range constant is accomplished by repetitive counting. Figure 3-11 shows a block diagram of the multiplier. If the Cursor Position Count is 300, corresponding to a frequency 30% of full scale, and the the analysis range is 50 kHz, the proper

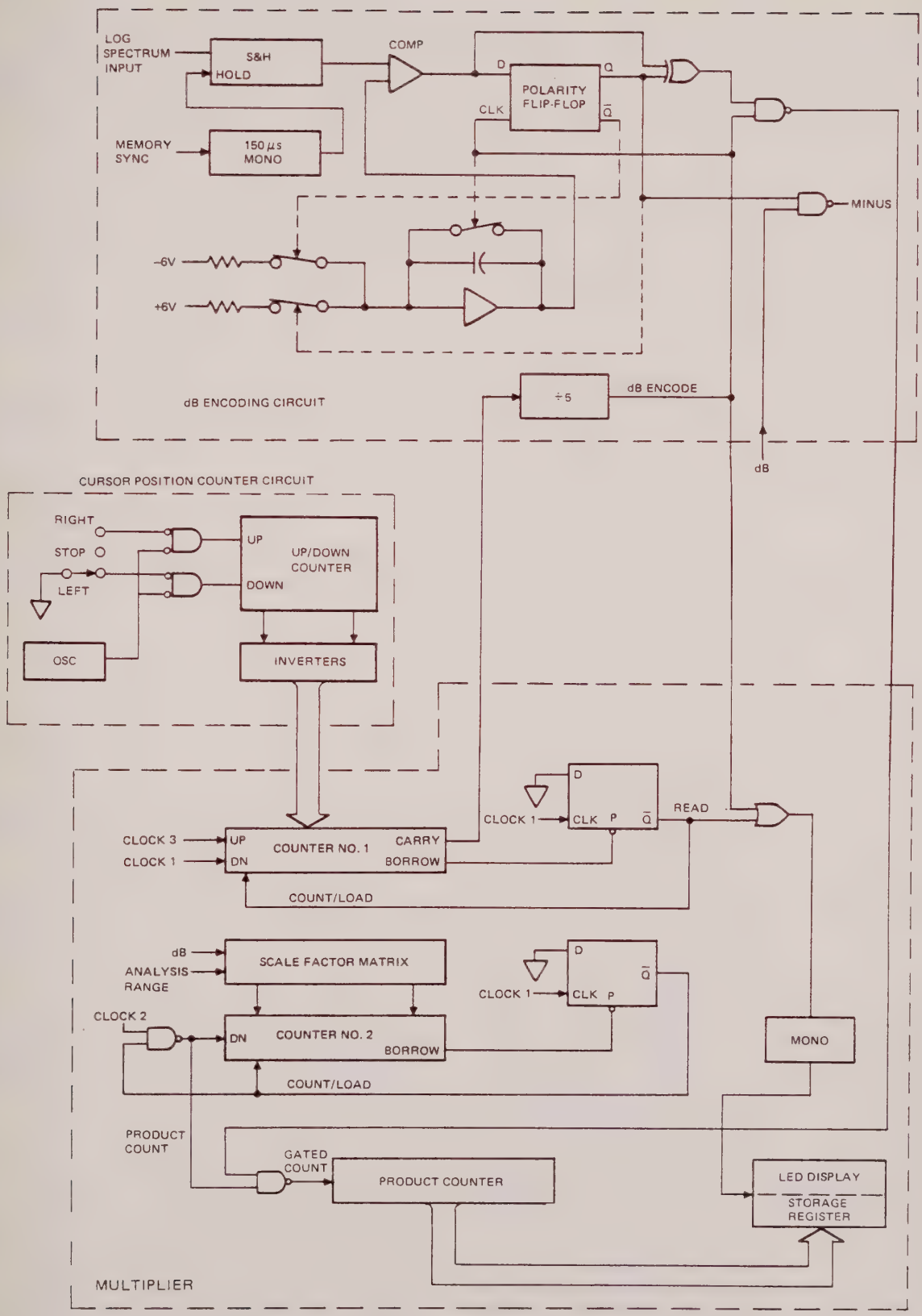


Figure 3-11. Cursor Position Block Diagram

display is 15000 hertz. To obtain this number in the Cursor display the Cursor Position Count is loaded into down counter No. 1, 50 is selected by the scale factor matrix and loaded into down counter No. 2, and then the product counter is set to zero.

Down counter No. 2 counts clock No. 2 for 50 counts, produces a borrow and resets to its initial state. The product counter accumulates 50 counts. Clock No. 1 counts counter No. 1 down one count to 299. Down counter No. 2 counts out 50 more counts and the product counter has accumulated 100 counts. The cycle continues with counter No. 2 generating 50 counts for each count of counter No. 1. When counter No. 1 counts down from 300 to 0, the sequence is complete. At sequence completion, the product counter will have accumulated 300 pulse bursts of 50 pulses, or 15,000 counts. This count is strobed into the product storage register and all circuits are reset.

The product count is stored and displayed by H-P 5082-7300 numeric indicators. These indicators have built in storage registers and decoding logic which allows a BCD number to be strobed in and displayed as an Arabic numeral.

3.2.6.4 Amplitude Readout

In addition to displaying cell frequency in hertz, the Cursor displays the cell amplitude in dB. Figure 3-11 shows a block diagram of the dB Encoder (A24) which utilizes the multiplying circuitry of the multiplier shown in Figure 3-11 in conjunction with a dB encoding circuit. To gate pulses into the product counter the dB encoding circuit produces a pulse width proportional to the LOG SPECTRUM input.

The sample and hold circuit (S&H), see Figure 3-11, is in the hold mode whenever MEMORY SYNC pulses are present. MEMORY SYNC pulses are momentarily stopped whenever the X-axis count agrees with the Cursor position, producing an intensity spot on the display* and holding the spectrum for that cell location. An interruption of the MEMORY SYNC pulses allows the output to go false placing the sample and hold circuit in the sample mode. When in the sample mode the S&H has a d-c voltage corresponding to the spectral output of the intensified cell. The action of the sample and hold circuit is independent of the dB encoding action.

*For dual displays in the dB mode the bottom display only is intensified.

Upon receipt of an encode command the spectral output is encoded by the following procedure. Clock No. 3 causes the counter No. 1 to count up and generate a carry pulse with every 5th pulse initiating a dB encoding. The comparator state, determined by the held voltage value and the integrator output voltage, is strobed into the polarity flip flop by dB encode going true. The integrator capacitor is shorted initially with an integrator output of 0 volts. The polarity flip flop turns on the appropriate switch to cause the integrator to slew toward the held spectral value. The shorting switch across the integrator capacitor is opened by dB encode going true. As the integrator slews toward the held spectral value, counter No. 2 generates pulse bursts of 6 each as selected by the scale factor matrix.

When the integrator voltage equals the held spectral value, the comparator output changes state and shuts off the gated count into the product counter. Counter No. 1 continues to count and at overflow produces a carry. The divide by five counter changes state and dB encode goes false causing the read mono to be fired which strobes the contents of the product counter into the display registers and then resets the product counter. The dB readout circuitry is now in the reset mode waiting for the next Encode command.

3.2.7 Clock (See Figure 3-12.)

The clock generates the timing signals that synchronize all internal operations. A 15.000 MHz crystal-controlled oscillator provides the basic clock frequency for the high-speed D/A converter (A1) and memory units (A3 through A11). A series of digital divider circuits (flip-flops) are used to divide the 15-MHz signal down to the various clock and sampling frequencies. To ensure the overall synchronization of all timing functions, resynchronizing circuits are used. To compensate for counter delays, the sampling frequency, although divided down from the 15-MHz clock, is resynchronized before being routed to the A/D converter. (See logic elements A2A25 and A2A22 in Figure 3-12. Also the 3-MHz clock, also derived from the 15-MHz clock, is resynchronized and, in turn, is used to synchronize the divided-down 10-kHz clock.) (See logic element A2A5 in Figure 3-12.)

The 3-MHz clock is divided by 10 to produce 300 kHz, and then further divided by a series of divide-by-5 and divide-by-2 flip-flop circuits to produce the sampling frequencies. Each sampling frequency is applied to a gate that is controlled by the front-panel ANALYSIS RANGE control. As each RANGE is selected, the proper gate is

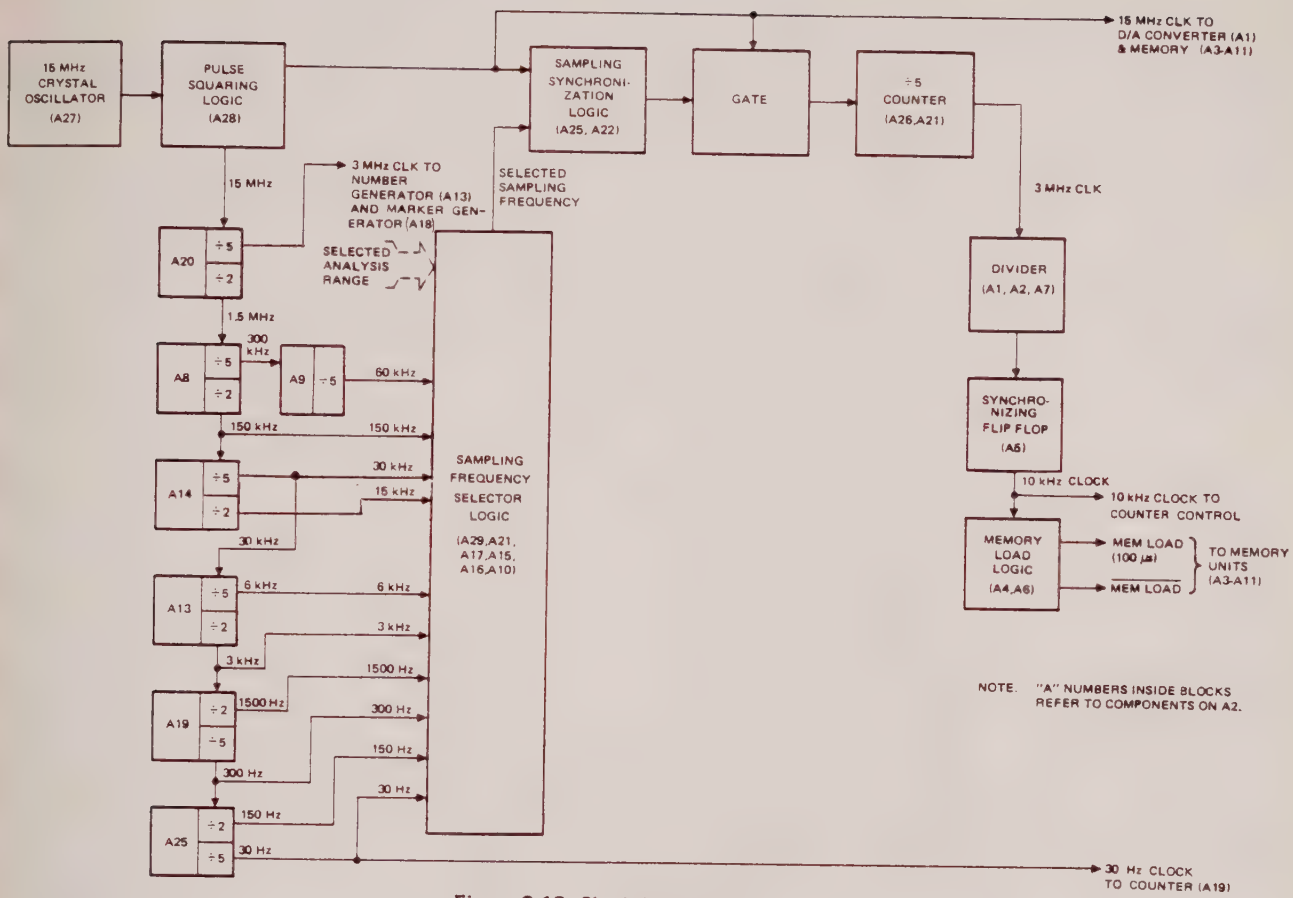


Figure 3-12. Clock Block Diagram

enabled allowing resynchronization of the correct sampling frequency signal. As previously described in the time compression section, the sampling frequency is always three times the RANGE UPPER LIMIT frequency. For example, with the ANALYSIS RANGE control set to 10K UPPER LIMIT (Hz), the 30-kHz signal is gated through for use as the sampling frequency.

The 15-MHz clock is also divided by 1500 to produce the 10-kHz clock. After synchronization by the 3-MHz clock signal, the 10-kHz clock is routed to all applicable points. The memory load logic, fed by the 10-kHz clock, supplies the control signals for loading the memory units in the time-compression section.

3.2.8 Power Supply (See Figure 3-13.)

Conventional solid-state diode rectifiers and electronic voltage regulators are used to provide all circuit d-c operating voltages: +28V, +12V, +5V, and -12V. All components are conservatively rated. The 115/230V, 50–400 Hz a-c input power is fused and filtered, and routed through the front-panel POWER push button switch to power transformer T1. The rear-chassis 115/230 slide switch facilitates connecting the primary windings of T1 in parallel for 115V operation or in series for 230V operation. The multiple secondary windings of T1 supply the full-wave diode rectifier circuits.

The +28V is derived form a +45 unregulated source, and is referenced by a zener diode. The +12V and +5V regulators are referenced to the -12V supply which is referenced to a zener diode. Because the +12V and -12V supplies are used extensively by operational amplifier circuits, the amplitude of the +12V regulated output is caused to track the -12V supply; that is, although opposite in polarity, both the -12V and +12V are always equal in amplitude.

The +5V supply, used mainly by integrated circuit elements, employs SCR "crowbar" circuit to prevent an overvoltage condition. If the voltage tries to rise above +5V, the overvoltage sense circuit drives the SCR into conduction. The SCR in turn shorts the unregulated 12 volts to ground, thus causing the fuse to open the circuit.

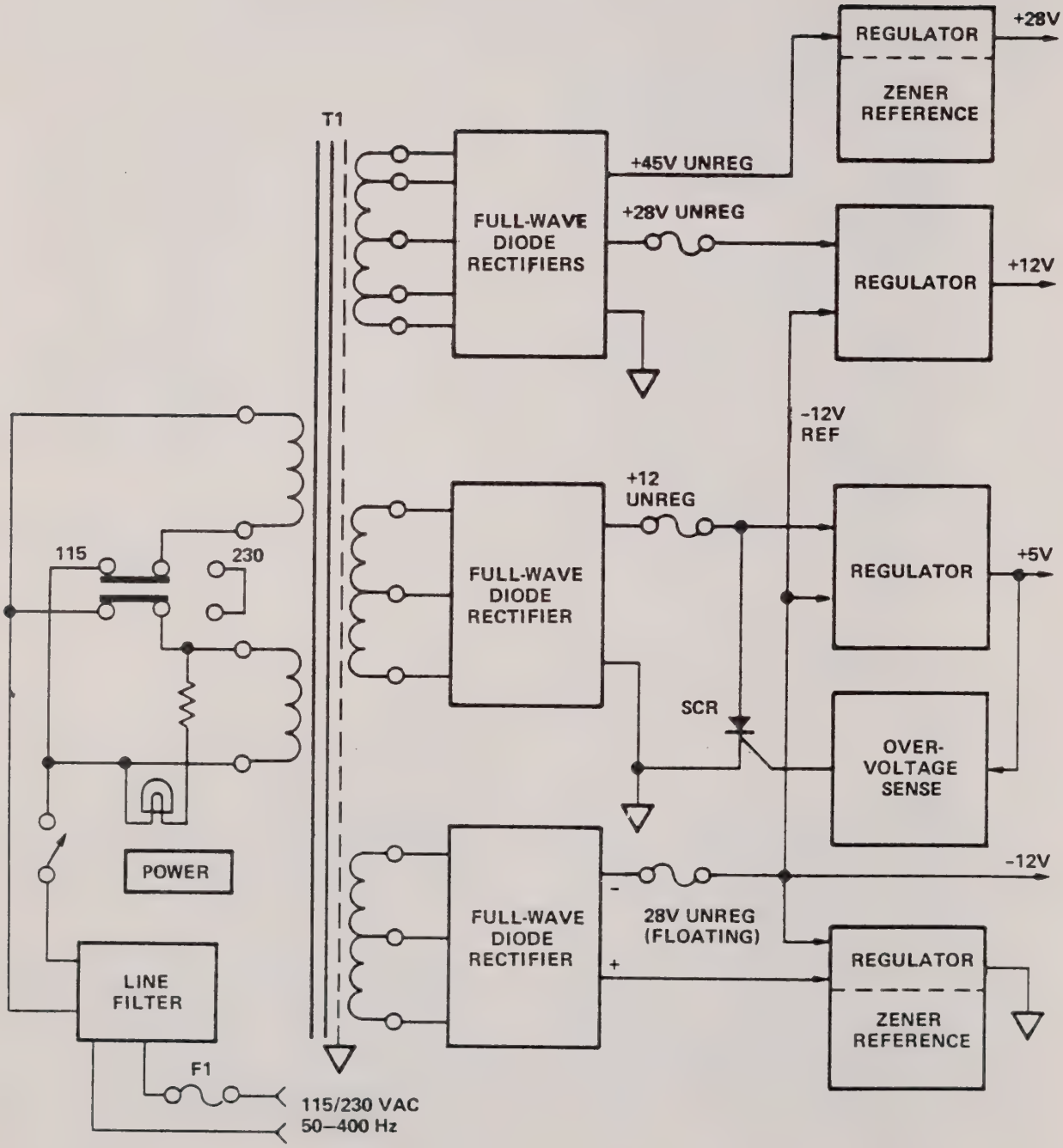


Figure 3-13. Functional Block Diagram of Power Supply

3.2.9 LOCAL/REMOTE Control (S19)

When the RTA is in the REMOTE mode of operation, INPUT RANGE, ANALYSIS RANGE and GAIN parameters are remotely controlled and can be remotely sensed.

Remote Control Signal Consideration

Standard TTL levels are applicable. A remote control "ON" is established by a closure to ground (not to exceed +0.5V) capable of sinking 3 mA, and with a series resistance of not over 200 ohms including the cable resistance.

A remote control "OFF" is established by an open circuit or connection to +5V (+3V minimum). The current drain at +5V is approximately 0.5 mA.

A sense output "ON" signal is +3V to +5V, and is capable of delivering up to 10 mA.

A sense output "OFF" signal is 0V to +0.5V, and is capable of sinking 16 mA.

A minimum settling period of 10 milliseconds should be allowed after a remote control is initiated on all functions except the ANALYSIS RANGE which requires a settling period of 500 milliseconds per step. Because this switch rotates only clockwise in the REMOTE CONTROL mode, and there are 2 blank positions between the 50K and the 10 Hz switch settings, be sure to allow an additional 1 second when changing to a lower range setting.

The sense strobe inputs, "A" through "D," may be strobed at rates up to 200 kHz.

3.2.9.1 INPUT RANGE and GAIN Remote Selection Control

The remotely controlled selector circuits for the INPUT RANGE (both Coarse and Fine) switches and GAIN switch operate in a similar manner. A binary coded number, representing a particular switch position, is applied from a remote source. The binary number is decoded to provide an individual control signal. The signal is amplified and activates a relay; the relay contacts perform the desired switch function. For example, as shown in Figure 3-14, position 5 of the Fine INPUT RANGE attenuator is being remotely selected.

NOTE: In each of the following descriptions, it is assumed that the front-panel LOCAL/REMOTE CONTROL switch is set to REMOTE; the L/R relay is energized. For sake of clarity, the L/R relay is included in each of the simplified schematic diagrams.

In Figure 3-14, the binary number 0101 (decimal 5) is applied to the address inputs of the binary number decoder. The decoded output enables the "5 dB" relay driver and relay. The subsequent contact closure selects the fifth step of the attenuator network. In like manner, any binary input number from 0000 to 1001 will cause the corresponding attenuator step, 0/CAL, to 9 dB, to be selected.

The Coarse INPUT RANGE switch circuitry shown in Figure 3-15 operates similarly to that described above. However, additional relay contacts on the "10 dB" relay and the L/R relay are used to perform the switching function for S2B.

In the GAIN selector circuitry (see Figure 3-16), only a simple binary-to-binary level conversion is made. In LOCAL CONTROL mode, the two wipers of GAIN switch S15A select 0V and 5V in binary coded combinations for application to circuit card A28 (Pins 19 and 20). In REMOTE CONTROL mode, two sets of relay contacts, controlled by two binary coded input lines, perform the switching function. Refer to the table in Figure 3-16; the circuit components that work together in pairs are enclosed in double vertical lines. Reading the table from left to right on the third line, "20 dB GAIN," the control signal input is binary 10. Relay K1 is energized, and K2 is de-energized. The outputs to A28-19 and A28-20 are +5V and 0V. (Observe that the outputs would be the same in the LOCAL mode with the GAIN switch set to 20 dB as shown in Figure 3-16.)

3.2.9.2 ANALYSIS RANGE Remote Selection Control

In the REMOTE CONTROL mode of operation, the ANALYSIS RANGE switch is mechanically set to the desired position by a built-in motor; the motor is an integral part of the ANALYSIS RANGE switch, S1. The motor rotates (steps) the switch clockwise only, in increments of 30 degrees. To allow 360 degrees rotation, the switch position sensing wafer, S1A, for the motor control circuit has 12 positions; 10 correspond to the 10 range positions, and the 2 additional provide continuity of rotation.

See Figure 3-17. Switch position numbers 1 through 10 have been assigned to the 10 ranges 10 Hz to 50 kHz. The switch is set to a desired position by remote application of an equivalent (minus 1) binary coded number. In the example of Figure 3-17, a binary 0011 control input (decimal 3) has caused selection of switch position 4, the 500 Hz range. In this static condition, the wiper of S1A has satisfied the input of the digital multiplexer by grounding input 3, the decimal equivalent of the binary input. In this condition, the multiplexer

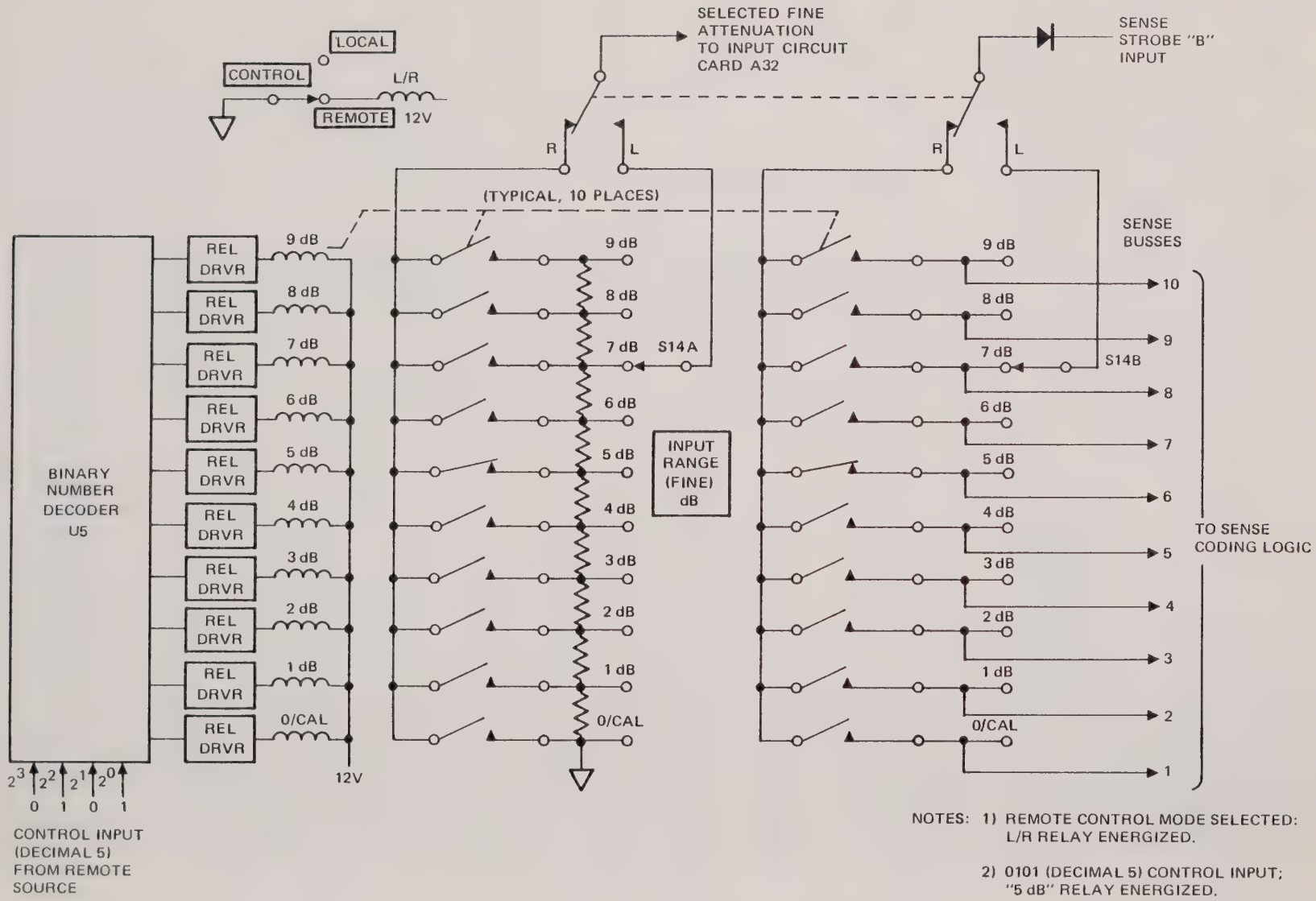


Figure 3-14. Simplified Schematic Diagram of Remote Control and Sensing Circuits for the Fine (1 dB/step) INPUT RANGE Attenuator

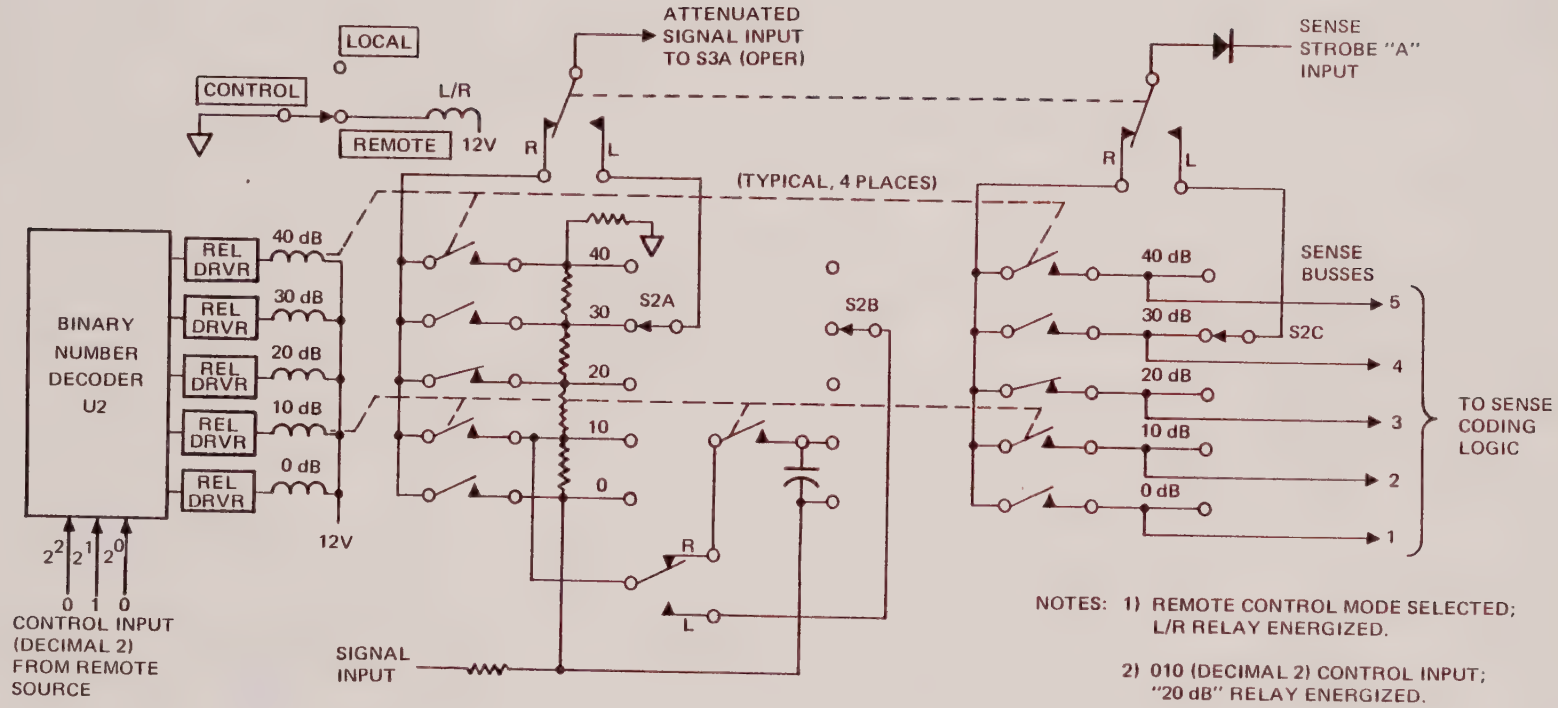
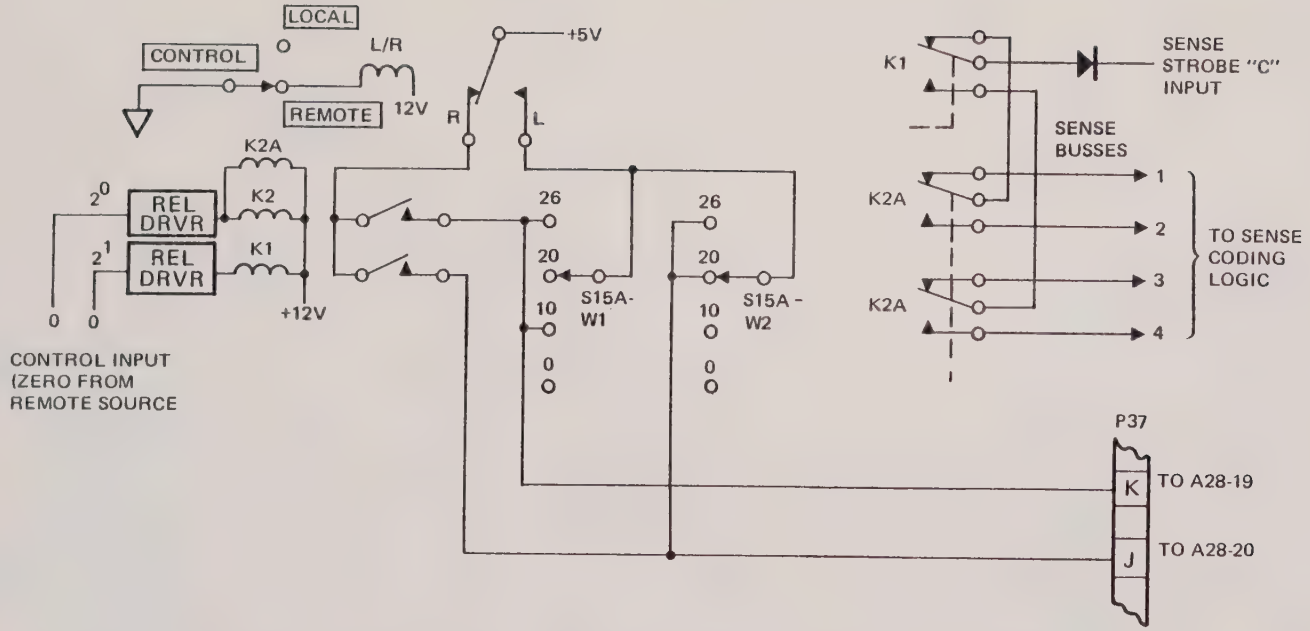


Figure 3-15. Simplified Schematic Diagram of Remote Control and Sensing Circuits for the Coarse (10 dB/step) INPUT RANGE Attenuator



GAIN	CONTROL INPUT	K1	K2 (K2A)	TO A28-19 (S15A-W1)	TO A28-20 (S15A-W2)	ENABLED SENSE BUS
0 dB	0 0	D	D	0V	0V	1
10 dB	0 1	D	E	0V	+5V	2
20 dB	1 0	E	D	+5V	0V	3
26 dB	1 1	E	E	+5V	+5V	4

D = DE-ENERGIZED; E = ENERGIZED

Figure 3-16. Simplified Schematic Diagram of Remote Control and Sensing Circuits for Post GAIN Selector

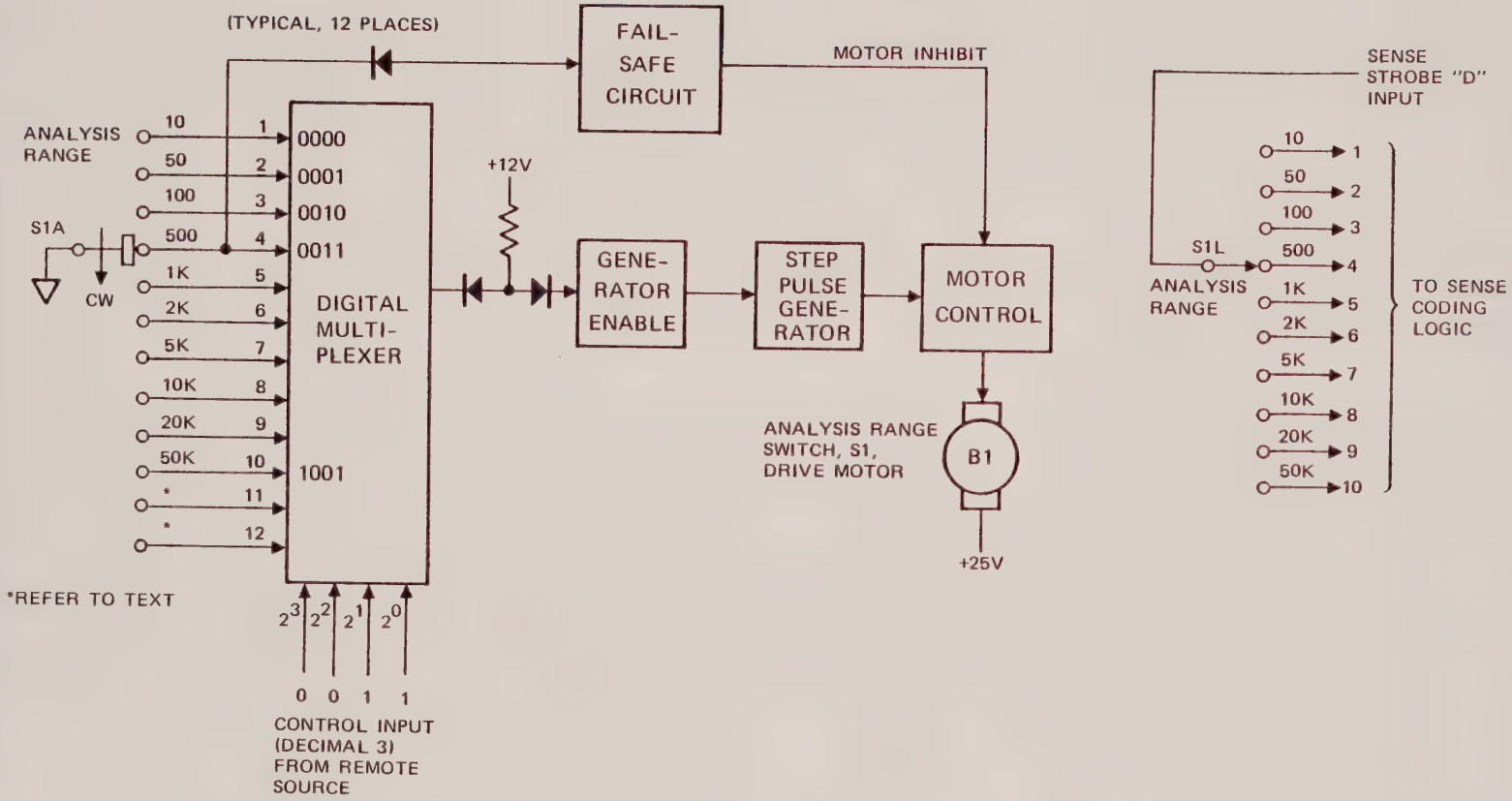


Figure 3-17. Functional Block Diagram of Remote Control and Sensing Circuits for the ANALYSIS RANGE Selector

output is high (+5V), the output of the generator enable is low, inhibiting the step-pulse generator and the motor stays de-energized.

A new range is remotely selected as follows: Assume that it is desired to change from the 500 Hz range to the 20 kHz range. Because the "20K" range is selected at switch position 9, a binary equivalent minus 1 (1000) must be applied to the control inputs of the digital multiplexer. This change causes the multiplexer output to go low, the generator control output goes high, and the step-pulse generator (a free-running oscillator) produces positive pulses, approximately 45 milliseconds wide and approximately 500 milliseconds apart. During each positive pulse, the motor control energizes the motor causing it to rotate clockwise 30 degrees. When the switch has stepped to position 9 (for this example), the S1A wiper applies ground to multiplexer input 9, and the motor switch circuitry assumes a static condition as previously described.

If the switch is inadvertently turned clockwise, it will automatically advance clockwise through 360 degrees and stop at the position dictated by the control input number. If a binary number higher than 9 (1001) is applied, no change will occur; the switch will stay in its present position.

A fail-safe circuit will inhibit the motor from turning if the switch fails to provide continuity between ground (on S1A wiper) and any of the 12 positions. Each of the 12 switch positions is connected through a diode to the base of a transistor switch. (Note that S1A is the make-before-break type switch.) If the ground connection becomes broken, the fail-safe circuit will inhibit the motor control, thus turning off the power to the motor. Furthermore, the generator enable and step-pulse generator circuitry is designed to inhibit the motor control if either the +5V or +12V power is removed.

3.2.9.3 Remote Sensing of Range and Gain Parameters and Overload Conditions

The parameters of the INPUT RANGE, GAIN, and ANALYSIS RANGE, and the status of the input and output OVERLOAD conditions can be sensed remotely. The sense information is available in both the LOCAL and REMOTE CONTROL modes of operation.

In LOCAL CONTROL mode, the physical position setting of the front-panel switches are sensed. An additional switch wafer has been added to each switch (INPUT RANGE Coarse and Fine, ANALYSIS RANGE, and GAIN). See Figures 3-14, 3-15, 3-16 and 3-17. In each case, each switch position has been assigned a position number, from 1 up to 10, starting with 1 for the lowest value parameter. Each switch wafer contact is connected to a correspondingly number sense bus.

For example, as shown on the right-hand side of Figure 3-14, the contacts of switch wafer S14B are connected to sense busses 1 through 10. In the LOCAL CONTROL mode, the input sense strobe is applied to the wiper of S14B. The wiper of S14B applies the sense strobe pulse to the 8th position (7 dB), and thus to sense bus number 8. The 10 sense busses are routed to the sense coding logic, a 10-input NOR gate circuit. This circuit provides a 4-bit binary word whose value equals the decimal number assigned to the sense bus (and switch position) being strobed. See Figure 3-18.

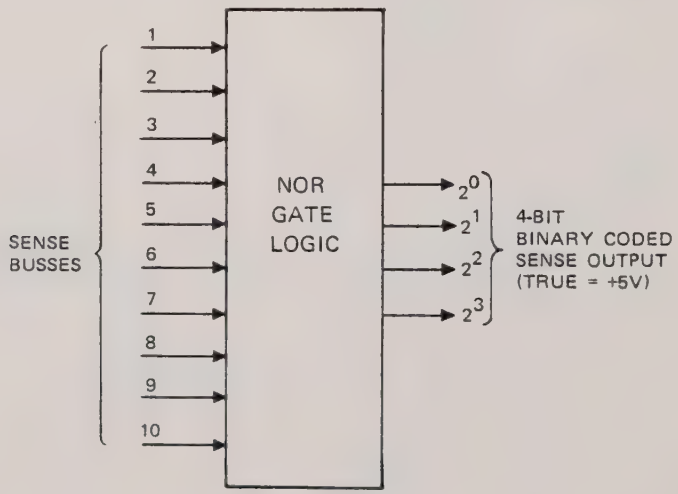


Figure 3-18. Block Diagram of Sense Coding Logic

In the LOCAL CONTROL mode, each of the front-panel switch positions is sensed in a similar manner. During normal operation, a sense strobe pulse (TTL ground) is sequentially applied to each sense strobe input, "A" through "D." In this way, the same 10 sense busses and associated NOR logic can be used for all 4 switches, to provide the switch position information.

In the REMOTE CONTROL mode, the ANALYSIS RANGE remote sensing operates the same as in LOCAL CONTROL mode. This is because in both modes, the switch is physically positioned to the desired range. That is, in LOCAL mode it is manually set; in REMOTE mode, it is motor driven to the desired position by remote control.

The INPUT RANGE and GAIN parameters are selected by remotely controlled relays. As shown in Figures 3-14, 3-15 and 3-16, an additional set of contacts on each relay provide the sensing information to the sense busses. The NOR gate logic and sense outputs are the same as previously described for the LOCAL mode.

The input and output OVERLOAD remote sensing circuits operate the same. See Figure 3-19. Each operates from its OVERLOAD lamp control circuit. For example, when an OUTPUT OVERLOAD condition exists, a ground level is applied to DS3, and DS3 lights. The same ground level is inverted and provided as a nominal +5V output level for application to an external computer. Note that the sensing circuits operate whether the OVERLOAD indicator lamps are burned out or not.

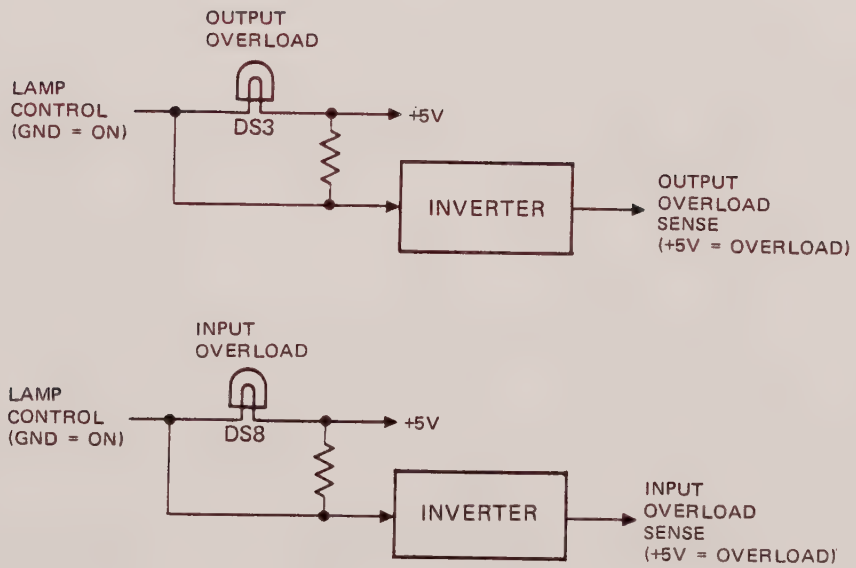


Figure 3-19. Functional Block Diagram of OVERLOAD Sensing Circuits

3.2.9.4 Remote Control of VCO and X-Axis Sweep

The VCO frequency (18–23 MHz) that is used to tune the filter in the analyzer section, is controlled by a variable d-c voltage output from the DAC. This d-c voltage is also outputted for use as the X-axis sweep control voltage. See Figure 3-20.

In any of the automatic sweep modes, the DAC is fed BCD numbers (0 to 999) from a counter that sequentially counts clock pulses. In MANUAL MODE, the Cursor Position supplies BCD numbers to the DAC, and any one of the 500 filter locations can be selected for viewing.

To control the VCO frequency and X-axis sweep remotely, the RTA is operated in the MANUAL MODE, and the Cursor Position is set to 000. MANUAL MODE can be selected locally, or remotely by applying ground to J30-18. Then BCD numbers can be applied to the DAC via rear-chassis connector J30, Pins 6 through 17. By proper programming, any desired sweep start point, stop point and rate, or a single filter location can be selected remotely.

CAUTION The Cursor position switch is not disconnected from the remote lines in the LOCAL CONTROL mode of operation. If it is necessary for the computer to operate totally independent of the analyzer, it will be necessary to remove control lines or electrically disconnect them by the appropriate use of diodes external to the RTA.

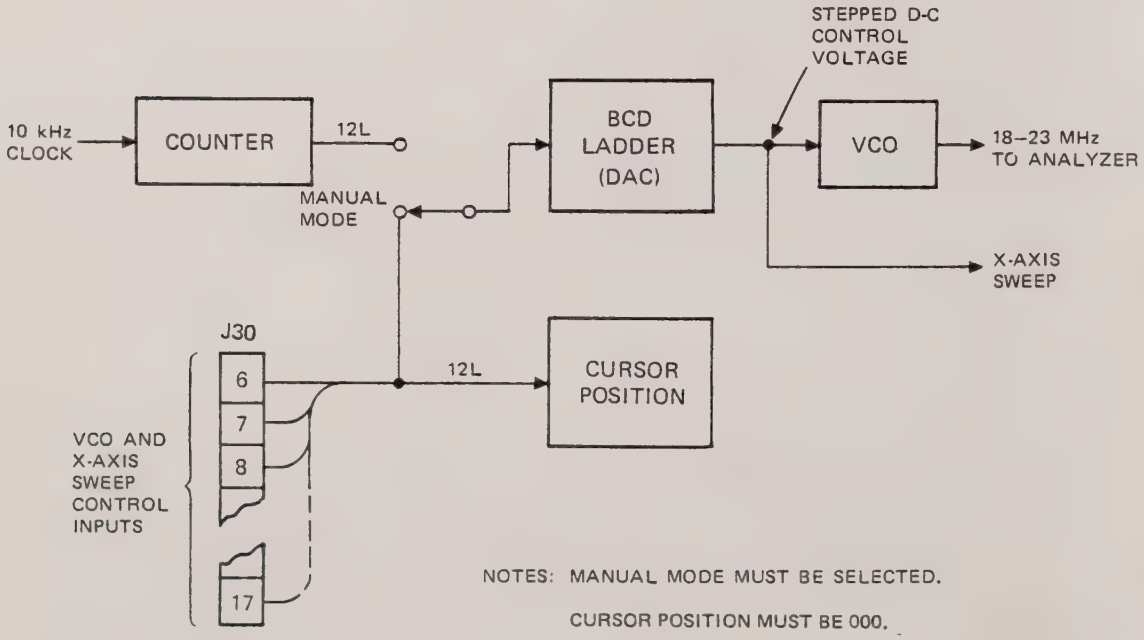


Figure 3-20. Functional Block Diagram of VCO and X-Axis Sweep Remote Control Circuit

SECTION IV

CALIBRATION AND MAINTENANCE

4.1 INTRODUCTION

This section contains instructions for the initial powering, operational checkout, calibration, troubleshooting, and parts replacement. Before performing the procedures contained in this section, study carefully the functional description of the front panel and rear of chassis controls, indicators, and connectors in Section I of this manual. Read each step of a procedure completely, including notes and cautions, before proceeding. Do not deviate from procedures unless the instruction states you may do so. It is important to study and fully understand Section III, Theory and Concept of Operation, before calibrating or troubleshooting the instrument. The Operational Checkout (Paragraph 4.3) should always be performed after calibration of the unit.

Figure 4-1 is a top view with the cover removed showing card locations. In this section test points and components that are mounted on circuit cards are referenced by alphanumeric designators that identify the circuit card as well as the component. For example, A1R1 is circuit card 1, resistor 1. Circuit card pin connections are referenced by the circuit card designator, hyphen, and pin number or letter, such as A1-1. The related receptacle terminals are shown as XA1-1. Other circuit card terminals are designated by an E, for example A1-E1; -E if they connect to leads outside the card, A1-E1. Access to calibration Controls is facilitated by the use of an extender card (A30). To force potentiometers fully counterclockwise, turn 20 turns counterclockwise.

CAUTION

Before extending a circuit card, remove power from the instrument. Be careful to face the component side of the circuit in the right direction. Reapply power to the instrument only after card is installed on the extender card.

4.2 CALIBRATION PROCEDURE

The calibration of the RTA is divided into the following sections:

- Pre-cal of Ladders and Power Supply Adjustment
- Input Section
- X Axis and VCO
- Analyzer Section
- Output Section
- Dynamics Adjustments and Final Checks

A flow chart of the Calibration Procedure is given in Figure 4-2. Test equipment needed is given in Table 4-1.

Table 4-1. Test Equipment Required

Name/Model No.	Manufacturer
AC Voltmeter	
3400A	Hewlett-Packard
Digital Voltmeter	
3440	Hewlett-Packard
Oscilloscope	
454	Tektronix
Oscillator	
4200	Krohn-Hite
Frequency Counter	
5223L	Hewlett-Packard
Ladder Test Fixture	
SD35-1	Spectral Dynamics
Display Oscilloscope	
13116-2A or SD311	Spectral Dynamics
8-inch Coaxial Cable with Fittings	
RSMDEX-1 and RMDXK-1 insert	Burndy
RSCDEX-1 and RCDXK-1 insert	Burndy

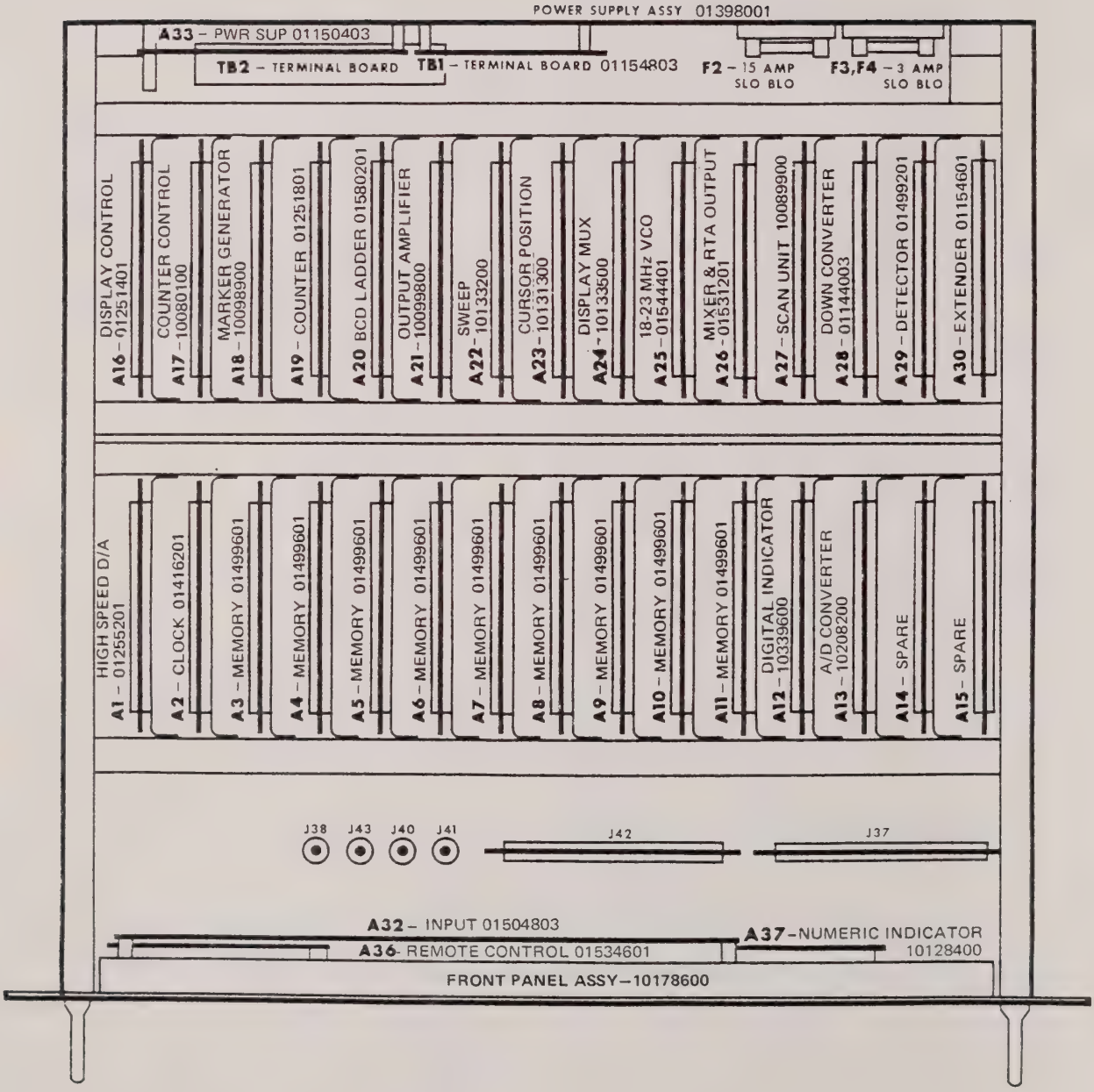

POWER SUPPLY ASSY 01398001
A33 – PWR SUP 01150403
TB2 – TERMINAL BOARD
TB1 – TERMINAL BOARD 01154803
F2 – 15 AMP SLO BLO
F3,F4 – 3 AMP SLO BLO
A16 – DISPLAY CONTROL 01251401
A17 – COUNTER CONTROL 10080100
A18 – MARKER GENERATOR 10098900
A19 – COUNTER 01251801
A20 BCD LADDER 01580201
A21 – OUTPUT AMPLIFIER 10099800
A22 – SWEEP 10133200
A23 – CURSOR POSITION 10131300
A24 – DISPLAY MUX 10133500
A25 – 18-23 MHz VCO 01544401
A26 – MIXER & RTA OUTPUT 01531201
A27 – SCAN UNIT 10089900
A28 – DOWN CONVERTER 01144003
A29 – DETECTOR 01499201
A30 – EXTENDER 01154601
A1 – HIGH SPEED D/A 01255201
A2 – CLOCK 01416201
A3 – MEMORY 01499601
A4 – MEMORY 01499601
A5 – MEMORY 01499601
A6 – MEMORY 01499601
A7 – MEMORY 01499601
A8 – MEMORY 01499601
A9 – MEMORY 01499601
A10 – MEMORY 01499601
A11 – MEMORY 01499601
A12 – DIGITAL INDICATOR 10339600
A13 – A/D CONVERTER 10208200
A14 – SPARE
A15 – SPARE
J38
J43
J40
J41
J42
J37
A32 – INPUT 01504803
A36 – REMOTE CONTROL 01534601
A37 – NUMERIC INDICATOR 10128400
FRONT PANEL ASSY – 10178600

Figure 4-1. Chassis Top View

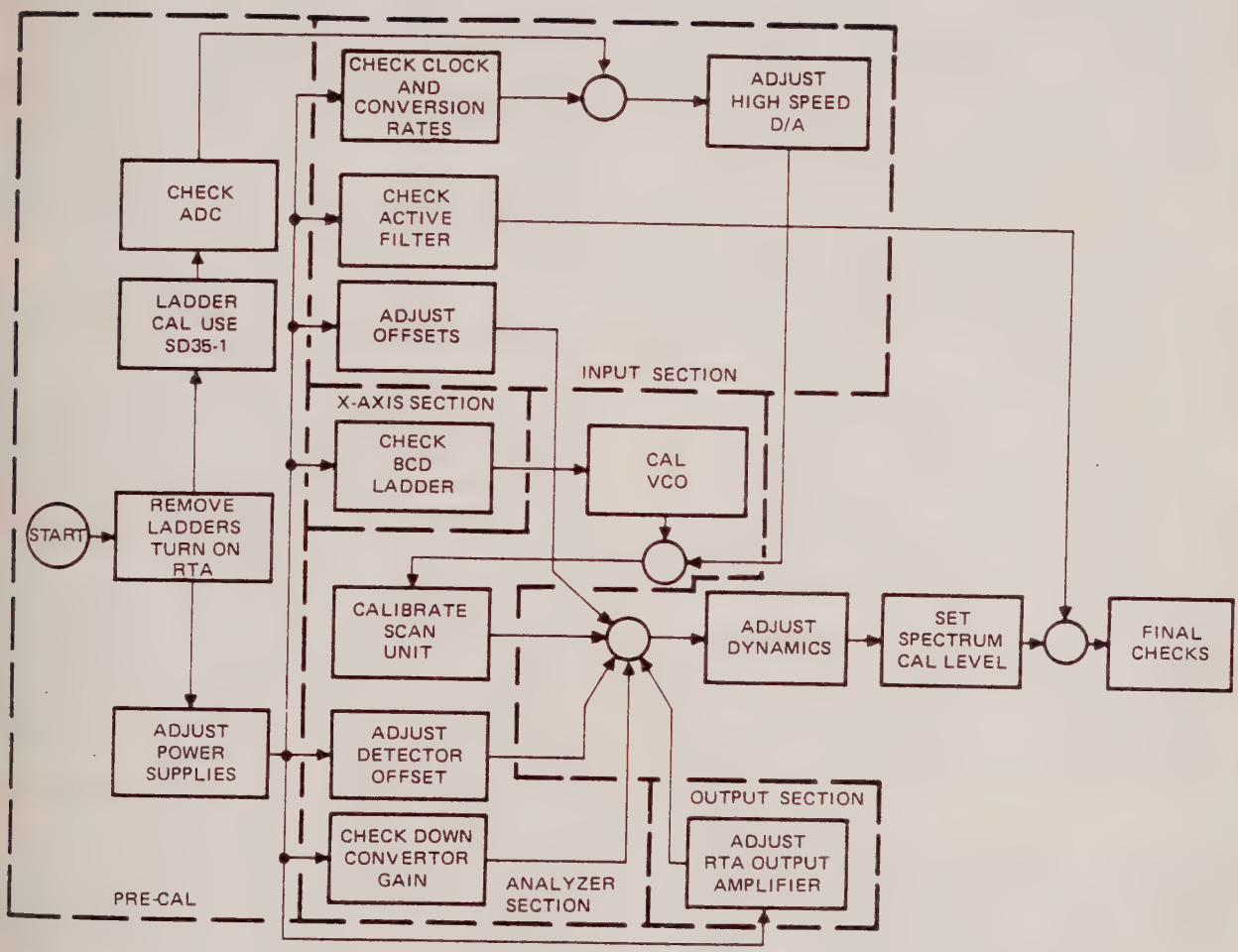


Figure 4-2. Calibration Procedure Flow Chart.

4.2.1 Pre-Cal

4.2.1.1 Ladder Pre-Cal And Equipment Setup.

a. Remove the high-speed D/A card (A1). Set the 115V/230V switch to 115V. Check for a 2-1/2 amp SLO-BLO line fuse. Apply power and allow 30 minutes for warm up.

b. Calibrate the ladder card (A1) using the Model SD35-1 Ladder Test Fixture; this can be done while the instrument is warming up. Use the calibration procedure included with the Model SD35-1 Ladder Test Fixture.

c. Remove power from the RTA and reinstall A1. Reapply power.

d. Connect the SPECTRUM LOG OUTPUT to the vertical input of an oscilloscope and the FREQUENCY LIN OUTPUT to the horizontal input of an oscilloscope (Model 13116-2A or equivalent). Calibrate the oscilloscope to the RTA outputs. The procedure is given in Section II of this manual.

e. Set front-panel controls as follows:

Control	Position
INPUT RANGE (Vrms)	
Coarse Adjustment	1 Vrms
Fine Adjustment	0/CAL
FREQUENCY MARKERS	OFF
MEMORY UPDATE	Lighted
ANALYSIS RANGE	2 kHz
OUTPUT GAIN	X1
OUTPUT OPER/CAL	SPEC LIN ZERO
DISPLAY MODE	RTA FAST
Sweep Initiation	AUTO
CURSOR MODE	OFF

4.2.1.2 Power Supplies

a. Monitor the power supply voltages at the top of the extender card with the card inserted into its chassis receptacle.

NOTE

In some models with optional features added, the extender card will not be installed in the A30 location. Check the manual addendum for extender card location.

CAUTION

To prevent possible shorting of the voltages and damage to the power supply, use a thin screwdriver having an insulated shaft to make the following adjustments.

Connect DVM (digital voltmeter) (Hewlett-Packard Model 3440 or equivalent) to each of the following pins of the extender card and adjust the associated control for the proper voltage. Check also for ripple voltage at each pin listed below.

Pin No.	Voltage	Adjust	Max. Ripple (mV p-p)
2	+28V ±10 mV	A33R15	20
22	−12V ±10 mV	A33R2	20
1	+12V ±10 mV	A33R5	20
21	+5V ±10 mV	A33R8	40

4.2.1.3 Input Analog to Digital Converter Calibration (A13)

a. Set the pertinent RTA controls as follows:

INPUT RANGE, Coarse Attenuator	1 Vrms
ANALYSIS RANGE	20 kHz
AC/DC	AC
DISPLAY MODE	RTA FAST (1)
OPER/CAL	OPER

b. Turn off RTA power, remove the integrated circuit A13U14 and extend circuit card A13 (ADC). Reapply power.

c. Connect the DVM to A13TP3.

d. Adjust A13R35 for 0 mv (±1 mV).

e. Jumper A13TP6 to ground. Adjust A13R27 for 2.5V (±1 mV). Remove jumper from A13TP6.

f. Jumper A13TP2 to ground. Adjust A13R50 for 156.2 mV (±0.2 mV). Remove jumper from A13TP2.

g. Turn off RTA power. Replace integrated circuit A13U14. Reapply power to the RTA.

4.2.2 Input

4.2.2.1 Input Filter (A32)

Optimize the gain and frequency response characteristics of the input (active) filter as follows:

a. Ensure that the test oscillator at SIGNAL INPUT (J24) is supplying 1 Vrms ±5 mVrms at 600 Hz. Output OPER/CAL switch to OPER, and switch A12S1 to out.

b. Observe the INPUT NORMAL indicator and adjust A32R63 until lamp is extinguished.

c. Now turn A32R63 in the opposite direction until the INPUT NORMAL indicator just lights; then continue turning A32R63 an additional one-half turn.

d. Using ac voltmeter, measure and note the dB level at A13TP9.

e. Increase frequency of the test oscillator for maximum reading on ac voltmeter. (Frequency will be approximately 2.1 kHz.)

f. Adjust A32C28 and/or A32C42 so ac voltage at A13TP9 is 0.2 dB ±0.05 dB more than noted in Step d.

NOTE

The dc output of the HP 3400A can be used to improve the accuracy of this measurement.

4.2.2.2 Input DC Levels and Clock Frequency

NOTE

Do not perform this procedure unless the input circuitry on input card A32 has just been serviced, or it is not operating properly.

a. Set INPUT RANGE coarse attenuator control to 10 Vrms, Fine attenuator control to 0 dB, and FREQUENCY MARKERS control to OFF.

b. Connect DVM to A32E60 (input card on front panel assembly), and adjust A32R5 for zero volts ±10 mV.

c. Connect DVM to A32TP6 and adjust A32R53 for zero volts ±10 mV.

d. Connect DVM to A13TP4 (A/D converter) and adjust A13R7 for 2.500 Vdc (±0.005 Vdc).

e. Check frequency at A2TP1 (clock card). If not 14.99 to 15.00 MHz, adjust A2C1.

4.2.2.3 High Speed D/A Ladder (A1)

a. Set the INPUT RANGE Coarse attenuator to 1 Vrms, the ANALYSIS RANGE control to 10k, and press the MEMORY UPDATE control.

b. Place the instrument on its right side (as viewed from the front), and remove the bottom cover.

c. Apply a 50 Hz triangular wave signal to the SIGNAL INPUT. Adjust the test oscillator output control so that the OVERLOAD indicator just lights.

d. The memory is now filled. Press the MEMORY HOLD control.

e. Connect a high frequency oscilloscope (20 mHz bandwidth) to card connector XA1-3. (Do not extend card A1.) Trigger the oscilloscope from J21, MEMORY SYNC connector on the rear chassis. Use a probe with tip shield grounding provisions and ground directly to card connector XA1-4. The waveform should be an approximately 25 kHz triangular waveform with a discontinuity appearing at a 10 kHz rate. The waveform will be made up of steps, each about 67 ns wide and 2 mV high. The voltage steps were adjusted with the Model SD35-1 Ladder Test Fixture. If large transients are present, they can be reduced as prescribed in the following Steps, f. through j.

f. When the level makes a transition from one step to the next, transients may occur. They are caused by variance in propagation times for different signals in the ladder. Before making any adjustments to lessen them, **ensure that the transients are not stray pickup.** The bandwidth of this circuit is above 100 mHz; high frequency pulses are normally present and can cause confusion in nulling out the propagation transients. Proceed as follows:

g. Adjust in sequence, A1R1, -R3, -R5, -R7, -R9 and -R11 for minimum transients on the up-slope of the triangular waveform. These adjustments interact, so several trials may be required.

h. Adjust in sequence A1R2, -R4, -R6, and -R8 to minimize transients in the down-slope of the triangular waveform (several trials may be necessary).

i. Repeat Steps g. and h. for best results.

j. Place unit back on its base.

4.2.3 X-Axis Section

4.2.3.1 BCD Ladder (A20)

a. Set the OPER/CAL control to FREQ LIN ZERO.

b. Adjust A20R32 for 0V ±1 mV at A20TP1.

c. Set the OPER/CAL control to FREQ FULL SCALE.

d. Adjust A20R7 for a reading of 5V ±1 mV at A20TP1.

e. Set the OPER/CAL control to OPER, the DISPLAY MODE control to RTA FAST (1), and the CURSOR MODE control to OFF. Adjust test oscillator input for 1 Vrms input.

f. Extend A20 and connect oscilloscope to A20TP1. Trigger scope from LIN FREQ OUTPUT (front panel). Assure that a staircase waveform made up of 10 mV steps exists. Reinstall A20.

4.2.4 Analyzer Section

4.2.4.1 Voltage Controlled Oscillator (A25)

a. Set front-panel controls as follows:

Control	Position
FREQUENCY MARKERS	INT
ANALYSIS RANGE	2 kHz
GAIN	X1
OPER/CAL	0 dB
DISPLAY MODE	RTA FAST (1)
Sweep Initiation	AUTO
CURSOR MODE	INTENSIFY
Cursor Position	000 Hz

1. Extend A25.

2. Adjust A25L6 for a 5V p-p low frequency ramp at A25E2.

3. Adjust A25R8 for 75 mV ±75 μV between A25TP1 and A25TP2.

4. Reinstall A25 VCO.

b. **Span and Linearity Adjust.** The span control determines the number of frequency markers per sweep. The linearity control affects the relative spacing between markers. The controls are adjusted as follows:

1. Set the OPER/CAL control to OPER. Adjust front panel Frequency-Cal control until the first intensity marker (2nd vertical line on the graticule) is on top of frequency marker. Adjust A25R1 until the last intensity marker is also on top.

2. Set the Sweep Initiation control to MEMORY PERIOD. Adjust Frequency-Cal until the first intensity marker is again on top. Set the Sweep Initiation control back to AUTO and adjust A25R2 until the first marker is again on top. Adjust A25R1 until the 10th marker is on top. Continue adjusting Frequency-Cal, A25R1, and A25R2 in this sequence until all intensity markers are on top and do not shift position between AUTO and MEMORY PERIOD.

c. **10% Frequency Offset Adjust.**

1. Set the OPER/CAL control to 0 dB.

2. Ground A25 pin 14. Adjust A25R15 until the 30% frequency marker is at 20% of full scale (it should fall on the 3rd vertical graticule with an intensity marker on top).

3. Remove the ground from pin 14 and verify that the 30% marker moves one frequency marker.

4.2.4.2 Down Converter (A28)

a. Remove power and pull out down converter circuit card (A28). Remove the cover that shields the 17.8 mHz oscillator and 18 MHz I.F. subassembly on the down converter circuit card (A28) and extend the card in its proper location. Use a short coaxial jumper (8 inches maximum) with proper fittings to extend existing coaxial cable. (Drawing No. 10446500, Section V.)

b. Apply power and allow at least a 5-minute warmup. Ensure that Output GAIN control is set to X1 position. Set OPER/CAL control to SPECTRUM-CAL 0 dB.

Set DISPLAY MODE switch to MANUAL (5). A[illegible] FREQUENCY-CAL control for peak SPECTRUM [illegible] output.

c. Connect frequency counter to A28TP5. A[illegible] A28C13 (next to Y1 at bottom on 17.8 MHz Oscil[illegible] subassembly) for counter reading of 200 kHz ±1 kHz.

d. Remove power, reinstall metal cover over oscillator and I.F. subassemblies on circuit card A28, and reapply power.

e. Trigger oscilloscope internal and connect an X10 probe.

f. Disconnect the counter, and connect test oscilloscope to A28TP2. Using access holes in the side of the shield compartment, tune L2 and L3 for maximum amplitude [illegible] oscilloscope. Now adjust A28R13 (access hole just belo[illegible] L2) for 1.4V p-p.

g. Connect test oscilloscope to A27TP7. Sync scope [illegible] SWEEP TRIGGER.

h. Adjust INPUT RANGE fine attenuator for approxi[illegible] mately 1.4V p-p.

i. Connect test oscilloscope vertical input to A28TP1. Turn A28R12 fully counterclockwise. Adjust A28L1 for peak signal; then adjust A28R12 for 310 mV p-p.

j. Connect test oscilloscope to A28TP5 and adjust A28R20 for 6 to 8V p-p.

k. Reinstall down converter (A28 into its proper receptacle.

4.2.4.3 Detector (A29)

a. Remove power, extend detector card (A29) in the *extender card receptacle.* Set OPER/CAL control to OPER.

b. Connect DVM to A29TP1, and adjust A29R32 for 0V ±1 mV.

c. Connect DVM to A29TP2, and adjust A29R55 for 0 mV ±1 mV.

NOTE

Do not remove shield cover for the next two steps. A29R5 and A29R75 are accessible through holes in the side of the shield cover; A29R5 is near the top and A29R75 is near the bottom (connector end) of card.

d. Connect DVM to A29TP3, and adjust A29R5 for 0V ±1 mV.

e. Connect DVM to A29TP4, and adjust A29R75 for 0V ±1 mV.

f. Remove power, replace detector card A29.

4.2.4.4 Scan Unit (A27)

a. Remove power, extend the scan unit card (A27) in its receptacle, and reapply power. With the scan circuit card extended, the coaxial lead from the down converter (A28) must be extended using an 8-inch (maximum) coaxial jumper with proper fittings.

b. Ensure that the RTA front panel controls are set as follows:

Control	Position
INPUT RANGE	1 Vrms, 0/CAL
FREQUENCY MARKERS	OFF
ANALYSIS RANGE	10k
OUTPUT GAIN	X1
OPER/CAL	SPECTRUM-CAL 0 dB
DISPLAY MODE	RTA FAST (1)
Sweep Initiation	AUTO

c. Observe the signals on A27TP5 and A27TP6, trigger on A27TP5.

d. Adjust A27L1 for a 90° relationship between the square wave on A27TP5 and the filtered signal on A27TP6.

e. Connect display oscilloscope vertical input to J2, horizontal input to FREQUENCY LIN (J17).

f. Adjust A27L4 for maximum amplitude on display oscilloscope.

g. Remove power, and reinstall scan unit circuit card (A27) into its receptacle. Reapply power and allow 5-minute warmup.

h. The criterion for adjusting the scan circuit card controls is to achieve the narrowest possible filter shape with minimum baseline flaring of the SPECTRUM LOG output.

i. Connect the test oscilloscope to A27TP3 (use X10 probe) (trigger from A27TP5). Adjust A27R17 and A27R15 as necessary to achieve a 100% modulated sine wave 0.6V ±0.05V peak to peak (evaluate maximum excursion).

j. Connect the FREQUENCY LIN and SPECTRUM LOG outputs to the X and Y inputs of a display oscilloscope (Model 13116-2A or equivalent).

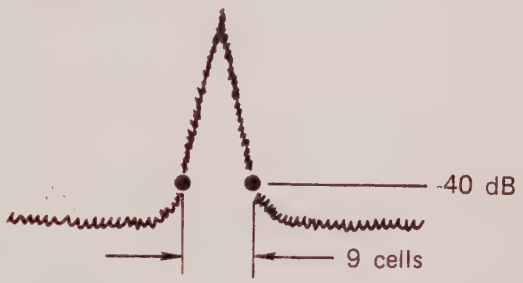
k. Adjust A27R22 counterclockwise until baseline flaring is observed. Now adjust A27R22 clockwise to minimize flare; stop adjustment when flare does not reduce further.

l. Change the display oscilloscope Y input from SPECTRUM LOG (J3) to SPECTRUM LIN (J2).

m. Adjust A28R20 for 4.7V p-p (+0.3V, -0V) baseline to peak, on the display oscilloscope. If A28R20 does not provide sufficient range, adjust A28R12. Repeat Steps i. through m. as necessary for minimum baseline flaring and still maintaining 4.7V p-p SPECTRUM LINE (J2) output.

NOTE

Adjust of minimum baseline flaring is very important. Evaluation of an optimum adjustment may be accomplished by moving the intensified dot through the spectrum peak display. Typically, the dot will span about 9 cells from the left 40 dB point to the right 40 dB point. See figure below:



NOTE

For proper display, it may be necessary to readjust step i. slightly and then repeat steps j. through m.

n. Adjust A28R20 for 5.1V peak on the display oscilloscope. The output overload light should light. Adjust A28R35 if necessary.

o. Adjust A28R20 for 4.7V peak.

4.2.5 Output Section

4.2.5.1 Output Amplifier (A21)

In this procedure the FREQUENCY and SPECTRUM output log converters are adjusted to provide a 1V full-scale output and a 40 dB dynamic range.

NOTE

1) Do not perform this procedure unless X-axis or Y-axis linearity problems are apparent between 0 dB and −30 dB. If problems only exist at −40 dB, this will be corrected on the final adjustment.

2) Do not perform this procedure with a Model SD309 Ensemble Averager connected.

3) If an Output Amplifier Assembly No. 11430-1 or 10099800 is installed, omit steps d. and e., then continue. If Output Assembly No. 11430-3 or 10099801 is installed, perform steps a. through e., then continue.

a. Remove power, remove detector card (A29) and set aside. Extend the output amplifier (A21), connect a jumper wire from A21TP1 to A21TP9 and reapply power. Adjust A21R48 (CLAMP) (Averager baseline clamp) fully counterclockwise.

b. Calibrate the FREQUENCY LOG output from the FREQUENCY-CAL positions as follows:

1. Set OPER/CAL control to FREQUENCY-CAL −1 DECADE and connect the DVM to A21TP7. Record the DVM reading.

2. Set the OPER/CAL control to FREQUENCY-CAL FULL SCALE. DVM reading should be ≈ 1V ±10 mV (400 mV ±10 mV more than in 1. above). Adjust A21R54, if necessary for a step of 400 mV.

3. Repeat Steps 1. and 2. as necessary.

4. Set OPER/CAL control to FREQUENCY-CAL FULL SCALE. DVM should read 1V ±5 mV. Adjust A21R24 if necessary.

5. Set the OPER/CAL control to FREQUENCY-CAL −2 DECADES. DVM should read 200 mV ±10 mV; if not adjust A21R8. If A21R8 is adjusted, steps 2. through 4. must be repeated, then step 5, as necessary.

c. The jumper wire added in step a. connects the FREQUENCY-CAL points to the SPECTRUM output. Calibrate the SPECTRUM-CAL (A21) RTA SPECTRUM (A26), output from the FREQUENCY-CAL points as follows:

1. Set the OPER/CAL control to FREQUENCY-CAL −1 DECADE and connect the DVM to A21TP (A26TP2). Record the DVM reading for for adjustmen in next step.

2. Set the OPER/CAL control to FREQUENCY-CA FULL SCALE. DVM reading should be ≈ 1V (400 mV ±10 mV more than in 1. above). Adjust A21R5 (A26R22) if necessary for a step of 400 mV.

3. Repeat Steps 1 and 2 as necessary.

4. Set OPER/CAL control to FREQUENCY-CAL FULL SCALE. DVM should read 1V ±5 mV. Adjust A21R28 (A26R25) if necessary.

5. Set the OPER/CAL control to FREQUENCY-CAL −2 DECADES. DVM should read 200 mV ±10 mV; if necessary adjust A21R11 (A26R17). If A21R11 (A26R17) is adjusted, steps 2. through 4. must be repeated, then step 5, as necessary.

NOTE

The following steps d. and e. apply only when circuit card A21, Assembly 10099801 is installed (Squared Output "-6" option).

d. Connect DVM to A21TP10, set OPER-CAL control to FREQUENCY-CAL FULL SCALE and adjust A21R61 for 3.5 ±50 mV.

e. Connect DVM to A21TP15 and adjust A21R77 for 4.9V ±50 mV.

f. On circuit card A26 turn A26R2 (RTA baseline clamp) fully CCW. Remove jumper end at A21TP9 and connect to A21TP2.

g. Perform steps c.1. through 5., except monitor A26TP2; then remove jumper between A21TP1 and A21TP2.

h. Replace A21 and A29.

4.2.6 Dynamics Adjustments

a. Set OPER/CAL control to SPECTRUM-CAL (0).

b. Adjust FREQUENCY-CAL control until corresponding points (cell locations) on either side of the corner frequency pip have equal amplitudes, as shown in the sketch below.

c. Adjust A28R20 to 4.8V peak LIN (J2), with RTA in position 1 (RTA FAST). Extend A29.

1. Adjust A29R96 for 4.8V peak SPECTRUM LIN (J2) with RTA in position 3 (RTA SLOW).

2. Adjust A29R95 for 4.8V peak SPECTRUM LIN (J2) with RTA in position 5 (Manual). Replace A29.

d. Adjust A27R22 for minimum baseline flaring and side lobe suppression with RTA in position 1 (RTA FAST) as seen at SPECTRUM LOG output (J3).

e. Continue to adjust A27R22, A28R20 until a 4.8V peak SPECTRUM LIN output (J2) with proper display width is obtained.

f. Set OPER/CAL to SPECTRUM LIN ZERO, set A12S1 to In, and adjust A12R12 for 80 mV pp ±10 mV at A32TP6.

g. Adjust A13R7 for best compromise for minimum spurs at −30, −40 and −50 dB levels.

h. Set the OPER/CAL control to SPECTRUM-CAL 0 dB; adjust A26R2 for an RTA baseline of −55 dB.

i. Set DISPLAY MODE Control to AVG (position 2).

j. Interconnect the SD309 Ensemble Averager to the RTA. Preset the SD309 as follows:

No. of ENSEMBLE SWITCH	16
MODE	EXP AVG
DISPLAY	SCOPE

P[illegible] and then START.

k. A[illegible] FAST and AVG log outputs are [illegible]

l. [illegible] Averager baseline of −55 dB.

4.2.7 Spectrum Level Set

The spectrum calibrate signal is generated on the marker generator card (A18). This calibration signal is always 3/10 of full scale frequency output regardless of the selected setting of the ANALYSIS RANGE control. A square wave is used for the calibration signal; therefore, the third harmonic is present in the spectrum output.

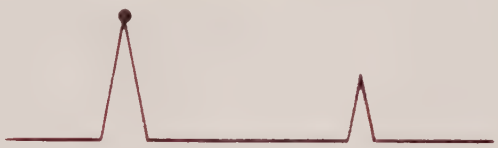
a. Connect test oscillator to the SIGNAL INPUT (J45). Adjust test oscillator frequency for approximately 600 Hz at 1 Vrms ±5 mVrms.

b. Set coarse INPUT RANGE control to 1, ANALYSIS RANGE control to 2k, DISPLAY MODE to RTA FAST (position 1), OPER/CAL switch to OPER.

c. Monitor LIN (J2) output and note amplitude.

d. Set OPER/CAL to SPECTRUM-CAL 0 dB. Adjust the FREQUENCY-CAL, if necessary, to maximize the spectrum amplitude. The amplitude of the spectrum line should be equal to ±5 mV to that of step b. If not, select a new value of A18R35 and A18R33 to obtain proper signal amplitude.

e. Set CURSOR MODE switch to INTENSIFY. Set OPER/CAL and INPUT RANGE fine attenuator controls to 0 dB. Using the CURSOR control, place the intensity marker at the peak of the CAL signal. See figure below.



Set Hz/dB control to dB. Adjust SPECTRUM-CAL (front panel) for a dB reading of 00.0 ±0.2. Set OPER/CAL control to −20 dB. Adjust A24R40 for a reading of −20.0 ±0.5 dB.

f. Remove power and test equipment, replace top and bottom covers, and place instrument in service.

g. Refer to −12B Instruction Manual Addendum for calibration of this printed circuit board.

4.2.8 Final Checks

a. Set ANALYSIS RANGE control to 2 kHz and OPER/CAL control to OPER, FREQUENCY MARKERS to EXT, push UPDATE. Apply a full scale signal to first J24, then J23, and then J45. Observe a spectrum as signal is applied to each input (output displays have unequal amplitudes).

b. Set OPER/CAL control to 0 dB and observe indicated outputs at the following jacks:

J52, J16, J17
0 to +5V 50 millisecond LIN sawtooth

J53, J18
0 to +1V LOG sawtooth

J54, J19, J20
Positive pulse once each 50 milliseconds approximately.

J57, J2, J1
Spectrum LIN output signal
J58, J3
Spectrum LOG output signal
J21
Positive pulse once each 100 μs
J22
Approximately 1.5 MHz 400 mV p-p square wave
J25
100 μs positive pulse once each 50 milliseconds
J10
Spectrum squared output. Signal only present if Output Amplifier assembly 11430-3 or 10099801 is installed.

c. As necessary, adjust comparator offset A13R7 for best dynamic range.

d. Check all ANALYSIS RANGES and adjust (if necessary) A28R35 to eliminate overloads. Some overload light flashing is normal when in the 10 Hz position.

e. Check frequency response on all ranges.

f. Verify post filter gain steps (10, 20, and 26 dB) ±1 dB.

g. Repeat Paragraph 4.2.2.3, steps g. and h., if necessary, to ensure minimum transients.

h. Run potential failure checks as follows:

1. Observe spectrum log output and sweep a tonal over the full frequency range for the 2 kHz analysis range; look for spurs, baseline breakup, amplitude nonlinearity, or any other indication of malfunctioning.

2. Adjust the +5V power supply (A33R8) to +4.75V.

3. Repeat step 1.

4. Adjust the +5V power supply (A33R8) to +5.25V and repeat step 1.

5. Return the +5 adjustment (A33R8) to +5.0V.

This completes the calibration of the RTA; however, the unit should now be checked by the operational procedure given in this section.

4.3 OPERATIONAL CHECKOUT

a. Set the front panel controls as follows:

Control	Position
INPUT RANGE	
Coarse Attenuator	20 dB
Fine Attenuator	0/CAL
AC/DC	AC
FREQUENCY MARKERS	OFF
TRANSIENT TRIGGER	INT
MEMORY	UPDATE LIGHTED
	(Press to light)
ANALYSIS RANGE	5 kHz
OPER/CAL	0 dB
GAIN	X1
DISPLAY MODE	RTA FAST (1)
Sweep Initiation Switch	AUTO
CURSOR MODE	OFF
CURSOR Position	0000 Hz
Hz/dB	Hz

b. Connect SPECTRUM LOG Output, J3, to display oscilloscope vertical input (200 mV/division sensitivity) connect FREQUENCY LIN Output, J17, to horizontal input (approximately 500 mV/division sensitivity). Ensure oscilloscope is dc coupled. Adjust oscilloscope so peak spectrum line is on a graticule line. See Figure 4-3. Observe that 3rd harmonic is approximately 1 division below (−9.5 dB) the fundamental peak; if not, adjust scope vertical sensitivity for an indication of 10 dB per division.

Fundamental should be at 30% of full-scale frequency.

The baseline as shown in Figure 4-3 is adjusted to provide 55 dB dynamic range. The baseline can be moved up or down as desired by adjusting RTA Baseline Clipper (A26R2).

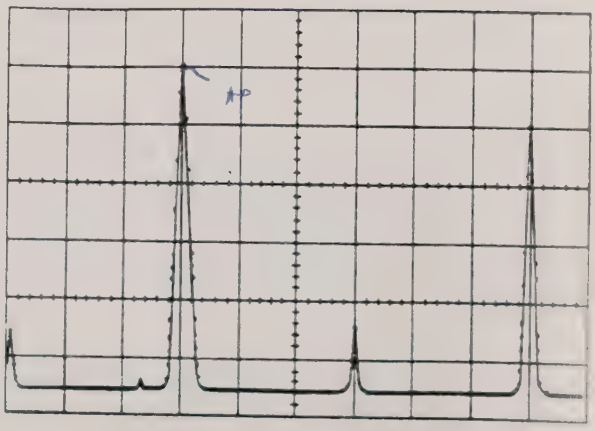


Figure 4-3. Calibration Signal.

c. Set GAIN control to X3.16 (10 dB); Output OVERLOAD indicator should light. Return GAIN control to X1.

d. Set DISPLAY MODE control to MANUAL (position 5); intensity marker should be near the same vertical graticule line as the fundamental (See Figure 4-4.) Adjust FREQUENCY-CAL potentiometer to ensure intensity marker is at peak amplitude.

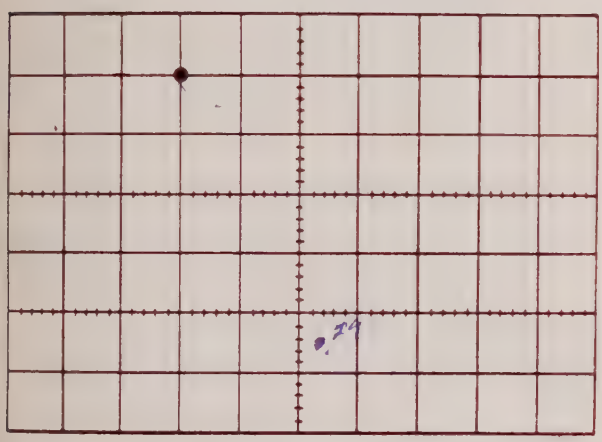


Figure 4-4. Intensity Marker at Peak of Calibration Signal Fundamental.

e. Set front-panel controls as follows:

DISPLAY MODE to RTA FAST (Position)
OPER/CAL to OPER
FREQUENCY MARKERS to INT
CURSOR MODE to INTENSIFY

Observe 10 intensity markers, one on top of each frequency marker. See Figure 4-5.

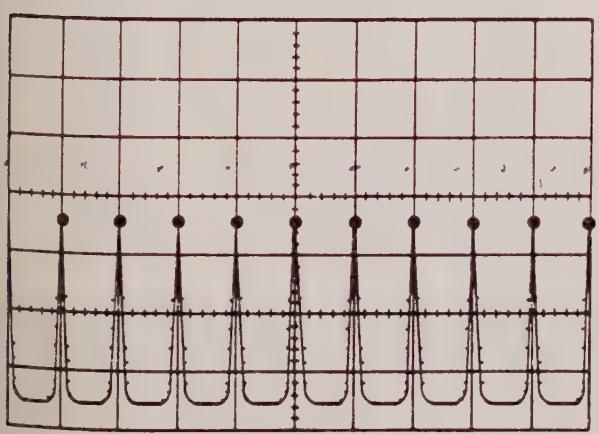


Figure 4-5. Frequency Markers with 10 Intensity Markers.

f. Set front-panel controls as follows:

FREQUENCY MARKERS to OFF
OPER/CAL to SPECTRUM CAL, 0 dB
ANALYSIS RANGE to 10 Hz

After approximately 50 seconds, the display should return to that shown in Figure 4-3 (except that 10 frequency markers are not present). Select each ANALYSIS RANGE setting up to 50 kHz; for each setting, wait the indicated MEMORY PERIOD SEC; and verify that display is as shown in Figure 4-3.

g. Check output linearity as follows:

1. Move Cursor intensity dot to peak of calibration signal. Set Hz/dB control to dB. Adjust SPECTRUM-CAL for 00.0 dB.

2. Set OPER/CAL control to SPECTRUM-CAL −10; verify a 10 dB decrease in output (1 division down on oscilloscope).

3. Set GAIN control to X3.16 (10 dB); verify a 10 dB increase in output (±0.5 dB).

4. Set OPER/CAL control to −20 dB; verify a 10 dB decrease in output.

5. Set GAIN control to X10; verify a 10 dB increase in output (±0.5 dB).

6. Set OPER/CAL control to −30 dB; verify a 10 dB decrease in output.

7. Set GAIN control to X20; verify a 6 dB ±1 dB increase in output (0.6 division on oscilloscope).

8. Set GAIN control to X1; verify a 26 dB decrease from X20 setting of Step 7.

9. Set OPER/CAL control to −40 dB; verify a 10 dB decrease in output.

10. Set OPER/CAL control to LIN ZERO; verify zero output. (Approximately −55 dB.)

11. Return OPER/CAL control to SPECTRUM-CAL 0 dB.

h. Check INPUT RANGE fine attenuator operation; verify a 1 dB ±0.3 dB (0.1 division on oscilloscope) change for each setting, 1, 2, 3, 4, 5, 6, 7, 8, 9. Return INPUT RANGE fine attenuator control to 0/CAL.

i. Set FREQUENCY MARKERS control to INT. Press and hold in the MEMORY HOLD control/indicator while setting OPER/CAL control to OPER; then release MEMORY HOLD control/indicator; indicator should remain lighted. The calibration signal is now held in memory.

j. Check operation of Sweep Initiation Control functions as follows:

1. Set DISPLAY MODE control to RTA SLOW (Position 3). Note increased flicker on output display.

2. Set DISPLAY MODE control to PLOTTER (Position 4).

3. Place Sweep Initiation Control to SINGLE RESET; SINGLE RESET control/indicator will light and sweep trace will start moving across the oscilloscope or,

4. Press SINGLE RESET control/indicator; indicator goes out and sweep track resets to extreme left and stays.

5. Press SINGLE RESET control/indicator again; indicator lights and sweep slowly scans outline of calibration signal and frequency markers. (dB readout is not valid.)

k. Set DISPLAY MODE control to MANUAL (Position 5), ANALYSIS RANGE to 10k. Hz/dB control to Hz; sweep trace will reset to the left. Move the Cursor address to 1000, 2000, and 3000; the intensity marker will appear at the top of the first frequency marker, the second marker, and then the calibration signal, in that order.

l. Check the operation of the SWEEP LIMIT mode:

1. Set DISPLAY MODE control to RTA FAST (Position 1), Sweep Initiation control to AUTO, CURSOR MODE control to SWEEP LIMIT, and Cursor address to 3000. Observe that only 30 percent of sweep is present on display oscilloscope.

2. Change Cursor address in increments of 100 from 3100 to 3900. For each setting, verify that sweep length increases proportionally in 1 percent increments.

3. Change Cursor address in increments of 20 between 3900 and 4000. Verify sweep length increases proportionally. Set CURSOR MODE control to OFF and push SINGLE RESET control/indicator.

m. Check out TRANSIENT CAPTURE mode as follow

1. Set FREQUENCY MARKERS control to OFF and ANALYSIS RANGE to 5k.

2. Set TRANSIENT TRIGGER control to INT.

3. Apply a full scale input signal to SIGNAL INPU connector (J45).

4. Turn INPUT RANGE fine attenuator to -9 dB.

5. Turn TRIGGER LEVEL control (pot) to -5 clockwise.

6. Push TRANSIENT CAPTURE control/indicato

7. Decrease INPUT RANGE Fine attenuator settin in 1 dB steps and verify that the unit goes into hold for a signal level greater than -5 dB (e.g., -3 dB).

8. Turn TRIGGER LEVEL control to -35 dB.

9. Attenuate input signal 40 dB and turn the INPU RANGE fine attenuate to -9 dB.

10. Push TRANSIENT CAPTURE control/indicator.

11. Verify that input will not trigger on noise.

12. Increase input signal in 1 dB steps and verify tha input will trigger on a signal smaller than -35 dB (e. -37 dB).

13. Return INPUT RANGE Fine attenuator to 0/CAL, INPUT RANGE to 1 Vrms.

14. Monitor MEMORY output (J22), trigger on MEMORY SYNC (J21), set oscilloscope time base to 10 μs per division. Memory contents are now displayed on the oscilloscope with the beginning of memory at the extreme right and the end of memory ten divisions to the left.

15. Set the CURSOR MODE control to TRANSIENT CAPTURE, CURSOR location to 999 and press the TRANSIENT CAPTURE control/indicator.

16. Momentarily apply a full scale signal to the input and observe the following sequence of events: TRANSIENT CAPTURE control/indicator goes out, UPDATE control/indicator momentarily lights and goes out, and then HOLD control/indicator lights.

17. Observe that memory is loaded over 6-2/3 divisions with the data level and zero for 3-1/3 divisions.

18. Repeat steps 15, 16, and 17 with the CURSOR location set to 500; observe memory is loaded with data level over 3-1/3 divisions.

19. Repeat with the CURSOR location set to 000 and observe that memory is loaded with all zeros.

n. Check modes from external inputs as follows:

1. Set TRANSIENT TRIGGER control to EXT. Set CURSOR location to 999.

2. Apply a 2.5V positive pulse to TRANSIENT CAPTURE (J8); TRANSIENT CAPTURE HOLD control/indicator will light.

3. Momentarily apply a full scale signal to the input (J45). Nothing should occur until a 2.5V pulse is applied at TRIG INPUT (J9). Apply the pulse to J9 and observe that transient capture occurs; TRANSIENT CAPTURE control/indicator goes out, HOLD control/indicator lights, and memory is filled with data level over 6-2/3 divisions.

4. Check out-of-band input signal OVERLOAD. Set ANALYSIS RANGE control to 10 kHz. Apply 20 kHz signal at +12 dB at SIGNAL INPUT (J45). The OVERLOAD indicator on the front panel should light. The NORMAL, 3/4, 1/2, and LOW indicators should not be lighted. Change SIGNAL INPUT to +11 dB, OVERLOAD indicator should go OFF.

This concludes the operational checkout for the Real Time Analyzer Unit.

4.4 PARTS REPLACEMENT

Except for some special SDC specification-controlled parts listed in Table 4-2, which must be ordered from Spectral Dynamics Corporation, standard electronic parts have been used throughout the instrument. Although standard, the pilot lamp bulbs, switches, fuses and power cord have been included to aid in their replacement. Spectral Dynamics Corporation maintains a complete stock of all parts and complete printed circuit card assemblies used in this instrument.

When ordering a replacement part or assembly, be sure to include the reference designation, the part number or manufacturer's designation, and a complete description; include also the instrument name, model number, and serial number.

Table 4-2. Special Replaceable Parts List

Reference Designator	Description	Part Number/ Mfr. Designation
A1	Circuit Card, High-Speed D-A	01255201
A2	Circuit Card, Clock	01416201
A3–11	Circuit Card, Memory	01499601
A12	Circuit Card, Digital Indicator	10339600
A13	Circuit Card, A/D Converter	10208200
A16	Circuit Card, Display Control	01251401
A17	Circuit Card, Counter Control	10080100
A18	Circuit Card, Marker Generator	10098900
A19	Circuit Card, Counter	01251801
A20	Circuit Card, BCD Ladder	01580200
*A21	Circuit Card, Output Amplifier	10099800/10099801*
A22	Circuit Card, Sweep	10133200
A23	Circuit Card, Cursor Position	10131300
A24	Circuit Card, Display Multiplexer	10133500
A25	Circuit Card, 18–23 MHz VCO	01544401

*Assembly 10099801 used for Squared Output "-6" Option.

Table 4-2. Special Replaceable Parts List (Cont.)

Reference Designator	Description	Part Number/ Mfr. Designation
A26	Circuit Card, Mixer & RTA Output Amplifier	01531201
A27	Circuit Card, Scan Unit	10089900
A28	Circuit Card, Down Converter	01144003
A29	Circuit Card, Detector	01499201
A30	Circuit Card, Extender	01154601
A32	Circuit Card, Input	01504801
A33	Circuit Card, Power Supply	01150403
A37	Circuit Card, Numeric Indicator	10128400
TB1	Terminal Board Assembly	01154803
A2Y1	Crystal, 14.98 MHz	20013-217-3
A21Q2,Q3 A21Q5,Q6	Transistors, 2N3391A, matched pair	20013-044
A25	Cover, VCO	10079900
A26Q1	Transistors, matched pair	20013-044
A27FL1	Filter, Bandpass, 6 MHz	21321500
A27FL2,3	Filter, Bandpass, 18 MHz	21327100
A32S1	Switch Index Assy., ANALYSIS RANGE	20013-401-5
A32S1A-K	Switch Wafer, ANALYSIS RANGE	20013-400-1
DS3–DS12	Lamp Bulb, OUTPUT OVERLOAD, LOW, 1/2, 3/4, NORMAL, INPUT OVERLOAD, TRANSIENT CAPTURE, UPDATE, HOLD, SINGLE/RESET	345 (Chicago Miniature of G.E.)
DS13	Lamp Bulb, POWER	A1H (Chi. Min. or G.E.)
F1	Fuse, POWER, 2-1/2A SLO, 3AG	Buss Littlefuse
F2	Fuse, +5V Supply, 10A SLO, 3AG	Buss Littlefuse
F3,F4	Fuse, +12, –12 SUPPLIES, 3A SLO 3AG	Buss Littlefuse
S2	Switch INPUT RANGE (Vrms) coarse, MODE	20013-322
S3	Switch, OPER/CAL	20013-236
S4	Switch, DISPLAY MODE	10151200
S5,S7	Switch, Sweep Initiation, FREQ MARKERS	7203(C&K)
S9–S12	Switch, Push Button; TRANSIENT CAPTURE, UPDATE, HOLD, SINGLE/RESET	54-61881-25 (MARCO OAK)
S13	Switch Push Button; POWER	54-61681-26 (MARCO OAK)
S14	Switch, INPUT RANGE fine–0/CAL	20013-324
S15,S16	Switch; OUTPUT GAIN, CURSOR MODE	20013-252
S18	Switch,	10608900
T1	Transformer, Power	20013-227
	Knob (double index), OUTPUT GAIN	20013-174
	Knob (single index), INPUT RANGE (Vrms), coarse and fine, ANALYSIS RANGE, MODE, OPER/CAL, CURSOR MODE	20013-175
	Knob,	20013-192
F.P.R50	Pot, SEPARATION	10548401
A29L4	Coil	20013-230
A29L5	Coil	20013-231
A29L6	Coil	20013-232
A29Q8,Q12	Transistors, 2N3391A Matched Pair	20013-045

4.5 TROUBLESHOOTING

One need not become an expert on the RTA to perform simple troubleshooting procedures that will in most cases isolate the problem. Pull out the foldout Figure 4-6 and see how simple the basic concept of operation really is. Here, we took the liberty of dispensing with an age-old problem, and put the "egg" first; then after some manipulation, ended up with the "chicken"!

Of course, knowing the overall theory of operation as described in Section III – at least to the functional block diagram level – is definitely an attribute. With that tucked away, the Troubleshooter's Functional Block Diagram, Figure 4-7 becomes a reality. So as not to clutter the drawing with every conceivable waveform, only the most pertinent have been drawn in; the rest are illustrated in Table 4-5 at the end of this section.

After meditating on the functional block diagram for awhile, proceed to the "RTA Troubleshooting Guide," Table 4-3. The statement usually inserted at this point reads something like this: "The Troubleshooting Guide does not attempt to list all the possible troubles that may occur in the instrument. However, it has been compiled from those troubles most frequently experienced by us and by our customers in the field." Unfortunately, the preceding statement is true, but we're including the table anyway, based on the following premise: If the instrument has been used in the approved configurations described in Section II, Operation, with some luck your RTA might experience only the same problems that we know about. If your particular problem is listed in the table, refer also to Figure 4-8, the Troubleshooting Tree; it should lead you out on the right limb.

Now if a problem does occur that cannot be cured after using all of the troubleshooting aids, please contact the Customer Services Department of Spectral Dynamics Corporation. They will work with you, using all of their experience and that of the Engineering Department, if necessary, to solve your problem. We haven't lost a "patient" yet!

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Table 4-3. RTA Troubleshooting Guide

Problem	Possible Solution
Spectrum line: instead of	1) Adjust A27R15 and A27R22 on Scan for proper weighting. 2) Weighting signal missing if this problem occurs at one group of frequencies.
Spectrum line dropout at one frequency	Ladder, High Speed DAC Calibration or bad current generator on either of these boards (A13 and A1).
Data Burst on display scope at particular amplitude or frequency	Bad memory, bad clock (the clock signal breaking up)
Base line growing weeds: 	Bad memory, bad clock (the clock signal breaking up)
Noise floor limiting (flat) i.e., dynamic range <54 dB	Adjust Detector per cal procedure (A29)
Lin Step Magnitude error	Adjust A27R17, A27R15, A27R22 on Scan for gain and weighting, respectively
Panic show!! Display (Spectrum Cal Signal)	Adjust A27R17, A27R15, A27R22 on Scan for gain and weighting, respectively

Table 4-3. RTA Troubleshooting Guide (Continued)

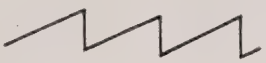
Problem	Possible Solution
Lin Step Output (freq.) missing – should be:  (ramp) but is:	Bad Counter which pulses the ladder and in turn the VCO
Lin Output (Spectrum or Freq) but no log output	Check Log Converters on X-Y Output Cards (A21)(A26)
Spectrum Linearity error at 30–40 dB (≅1–2 dB error only)	Slightly adjust ADC offset (A13R7).
Excessive Spectrum Linearity error	1) Re-cal ADC (A13) 2) Defect Comparator or S/H circuit 3) Defective Memory – check for pulses at A3TP5 – A11TP5
Display missing on one frequency range	Bad switch position S1 Bad gate on clock card A2
No Level Lamp indication – other lamps on	Look for Display control output to lamp drivers
All Lamps OFF – front panel dead	+5V Fuse located on top of power supply

Table 4-3. RTA Troubleshooting Guide (Continued)

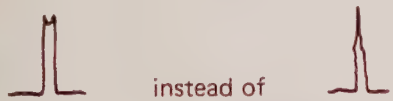
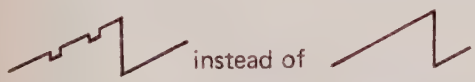
Problem	Possible Solution
Excessive local oscillator spur, i.e., zero freq. 	1) Adjust VCO scope Zero – such that L.O. is in view 2) Carefully adjust two chassis-mounted pots (MFR42 & MFR44) for min. 3) Re-cal VCO per procedure (A25)
Signal on Comparator S/H circuit but missing from MEM CONTENTS output	1) High Speed DAC Calibration (A1)
 instead of i.e., double peak	Ladder calibration (A13)
Ladder will not cal in one position	1) Defective input switching transistor (Q1–Q9) 2) Defective current generator (Q10–Q18)
Data dropout along X-axis – ladder ramp looks like:  instead of	1) Defective input switching transistor (Q1–Q9) 2) Defective current generator (Q10–Q18)
Spectrum display noisy	Memory driving F.F. in Number Generator (A13), i.e., improper memory input

Table 4-3. RTA Troubleshooting Guide (Continued)

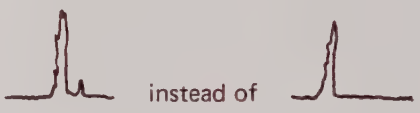
Problem	Possible Solution
Post Filter Gain inoperative	Relay A28K1 or A28K2 on Down Converter board sticking (A28)
Spectrum Linearity defective when using Range step attenuators.	Input offsets within Input Amplifier – perform calibration (A32)
 instead of	Defective 18 MHz crystal filter on Scan board (A27)
Spectrum distortion in region of –2 dec below full frequency scale	L.O. spur – Calibrate VCO (A25)
Transient Input defective	Display Control board defective (A16)
Pen Lift inoperative	Replace A16K1 on Display Control board (A16)
Small group of spurs at upper end of frequency range	Readjust A1R1-R8, R68, R69 on High Speed DAC (A1)
No spectrum data out – markers, however, OK	Trouble in Time Compression Section 1) Q28 on High Speed DAC (A1) 2) Exchange Ladders 3) Check Counter output

Table 4-3. RTA Troubleshooting Guide (Continued)

Problem	Possible Solution
Large offset between EXT AVG and SCOPE modes	Defective I.C. on Output Amplifier (A21) or RTA Output Amplifier (A26)
SCOPE mode display remains after switching to EXT AVG mode	Replace A26K1 on the RTA Output Amplifier (A26)
Frequency axis unstable, i.e., spectrum line jitters slightly along x-axis	Check power supply for stability and ripple
High frequency noise and simulated markers with markers switched off	1) Check Clock board frequency for 14.980 mHz (A2) 2) Remove one Memory board at a time and check operation (A3–A11)
Frequency axis very non-linear as seen by using the frequency markers	BCD ladder defective (A20)
Double peaked spectrum display after warmup	BCD ladder defective (A20)
Spectrum linearity very poor. Lin Spectrum output 2–3 volts instead of 5 volts	Check signal amplitude on Scan and Down Converter boards (A27 and A28) per calibration procedure

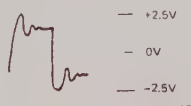
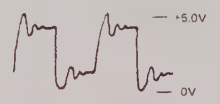
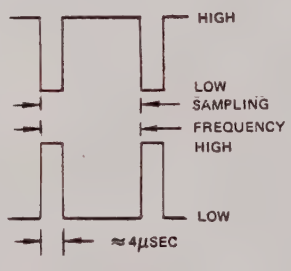
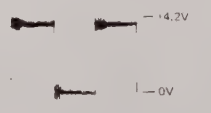
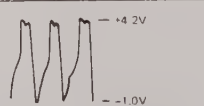
Table 4-3. RTA Troubleshooting Guide (Continued)

Problem	Possible Solution
Spectrum linearity defective. Also, the Y-axis base line drifts up and down	Check output amplifier I.C.'s for drift, particularly the RTA base line clamp circuit (A26)
Output goes dead after 30—60 minutes of operation	Check Detector board operation (A29)
Input lamps on without Signal Input. No SPECTRUM-CAL output	Check operation of Input board (behind front panel) (A32)
Excessive spikes along base line when signal applied	Check operation of High Speed DAC and Clock boards (A1 and A2)
Y-axis base line 10—20 dB above normal	Check calibration of Detector for offset voltages (A29)
Lower Frequency ranges noisy	Check Clock sampling frequency outputs (A2)
Spectrum noise and intermittent base line flutter	Check the Clock board operation, particularly the clock and $\overline{\text{clock}}$ outputs (A2)
Reduced Marker amplitude after warmup	Check Marker Generator board, particularly the marker output I.C. (A18)

Table 4-3. RTA Troubleshooting Guide (Continued)

Problem	Possible Solution
10 dB spur at 0.75 full scale in all ranges	Comparator not adjusted properly (A13) Check for 2.410V at A13TP4
RTA output display noisy when connected to SD307 or SD305	Normal operation if the SD305 or SD307 are off. Unit must be on.

Table 4-4. Testpoint Waveforms

ASSEMBLY	TEST POINT	WAVEFORM
A32	E8	
	TP1	
	TP2	
A13	TP9	SAME AS A32, TP2
	TP5	
A13	TP3	
A13	TP4	
	TP7	
	TP8	
A3-A11	TP1	
	TP5	
A1	TP1	 EXTENSION LEAD CONNECTED TO TP1 P.C. BOARD NOT EXTENDED

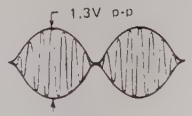
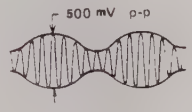
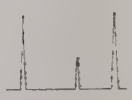
ASSEMBLY	TEST POINT	WAVEFORM
A27	TP4	
	TP3	
	TP5	10kHz
A28	TP1	P.C. BOARD EXTENDED
	TP2	
	TP3	
	TP5	
A29	TP1	P.C. BOARD EXTENDED
	TP2	SAME AS TP1
	TP3	
	TP4	
		

Table 4-4. Testpoint Waveforms (Continued)

ASSEMBLY	TEST POINT	WAVEFORM
A21	TP9	SAME AS A29-TP4 — P.C. BOARD EXTENDED FOR ALL WAVEFORMS
	TP4	+4.0V
	TP6	420 mV, 620 mV
	TP8	+1.1V, 0V, -50 mV
	TP2	SAME AS A29-TP4 & A21-TP9
	TP1	+5.6V, 0V
	TP3	+4.6V, 0V
	TP5	+0.5V, 0V, -0.62V
	TP7	+1.1V, 0V
A2	TP1	+3.6V, 0V, -0.2V — P.C. BOARD EXTENDED FOR ALL TEST POINTS
	TP2	+3.6V, 0V, +4.0V
	TP3	+4.6V
	TP4	0V
A18	TP1	+5.4V, +0.9V
	TP2	+3.0V
	TP3	+3.6V, 0V, -1.0V — MARKERS TO INTERNAL
A17	TP3	SAME AS A2-TP4
	TP2	+4.2V, 0V
A19	DIGITAL TUNING CONTROL NUMBER	+4.0V, 0V, MSB — FREQUENCY AND WAVEFORM VARIES WITH BIT NUMBER
A20	TP6	+5.6V, 0V
A26	PIN 5	+1.2V, 0V, -1.2V — P.C. BOARD EXTENDED
	PIN 8	0V — P.C. BOARD EXTENDED

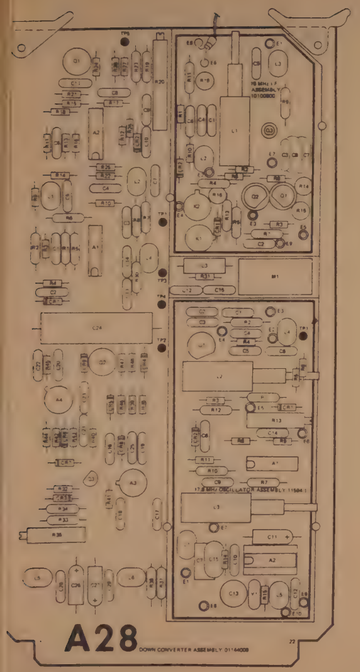
SECTION V

CIRCUIT DIAGRAMS AND COMPONENT IDENTIFICATION

5.1 INTRODUCTION

This section provides complete schematic coverage and individual circuit card component identification of the Model SD301D-C Real Time Analyzer. Generally, each printed circuit card type is presented as a separate drawing, with information relative to its interconnection in the instrument. However, for overall interconnecting information reference should be made to the following drawings:

FRONT PANEL INTERCONNECT (10180600)
MAIN FRAME INTERCONNECT (10180500)
POWER SUPPLY (10186300)



A28 DOWN CONVERTER ASSEMBLY 01144008

REVISIONS					
REV	STAT	LTR	DESCRIPTION	APP'D	DATE
A		0613	REDRAWN		5-5-74

NOTES UNLESS OTHERWISE INDICATED
1. (a) RESISTANCE SHOWN IN OHMS.
   (b) RESISTORS ARE 1/4 W ±5%.
   (c) CAPACITANCE SHOWN IN MICROFARADS.
   (d) CAPACITORS @ 12V.
2. DIODES ARE TYPE 1N914
3. ⚠ FACTORY SELECT WITH TYPICAL VALUE SHOWN.

HIGHEST REF DESIG USED
A4
CR9
C145
E10
K2
L8
M1
Q5
R148
TP5
Y1

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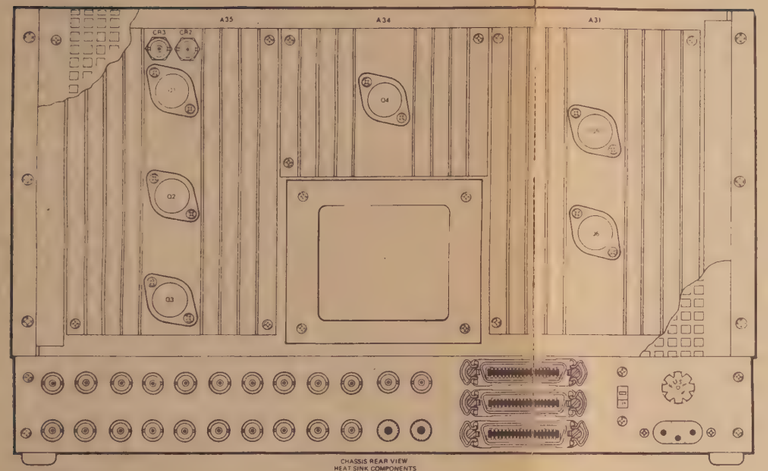
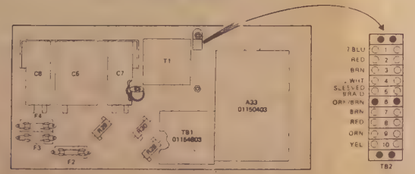
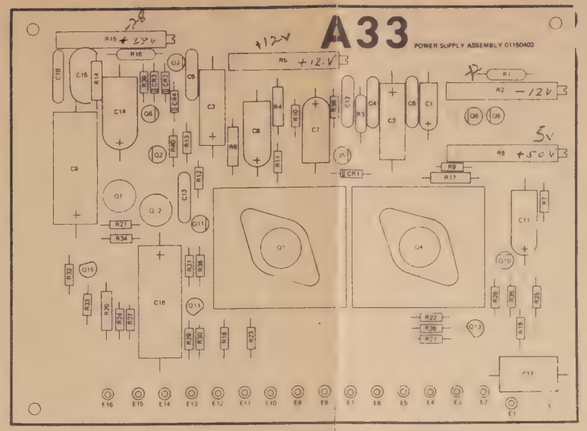
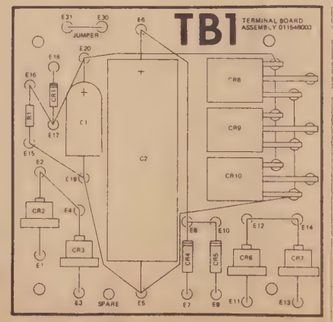
SPECTRAL DYNAMICS CORPORATION OF SAN DIEGO			TITLE: SCHEMATIC/COMPONENT LAYOUT DOWN CONVERTER ASSEMBLY 01144008			A28
DRAWN	L. SAUER	5-74	MODEL	SIZE	DRAWING NO	REV
DESIGNED			SD301D-C		T0330700	A
CHECKED		5-74	SCALE		SHEET 1 OF 1	
LOG USED		5-74				
APPROVED						

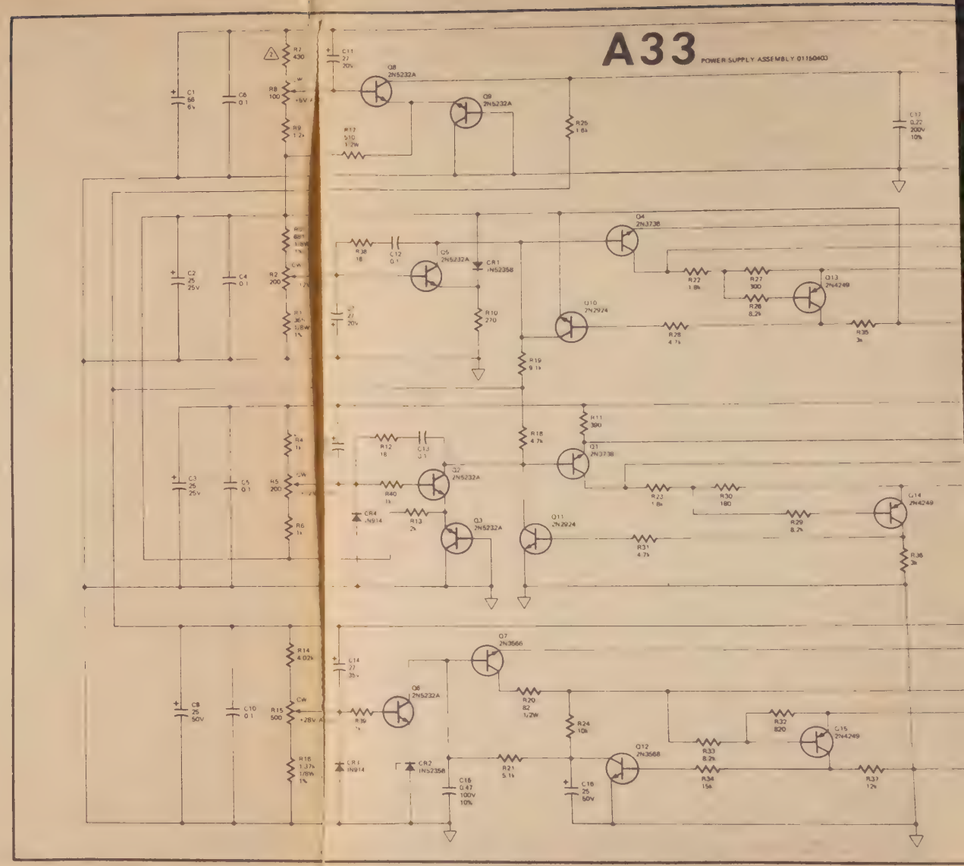
BOTTOM
TOP
REFER TO HEAT SINK DRAWING
A36
A34
A31

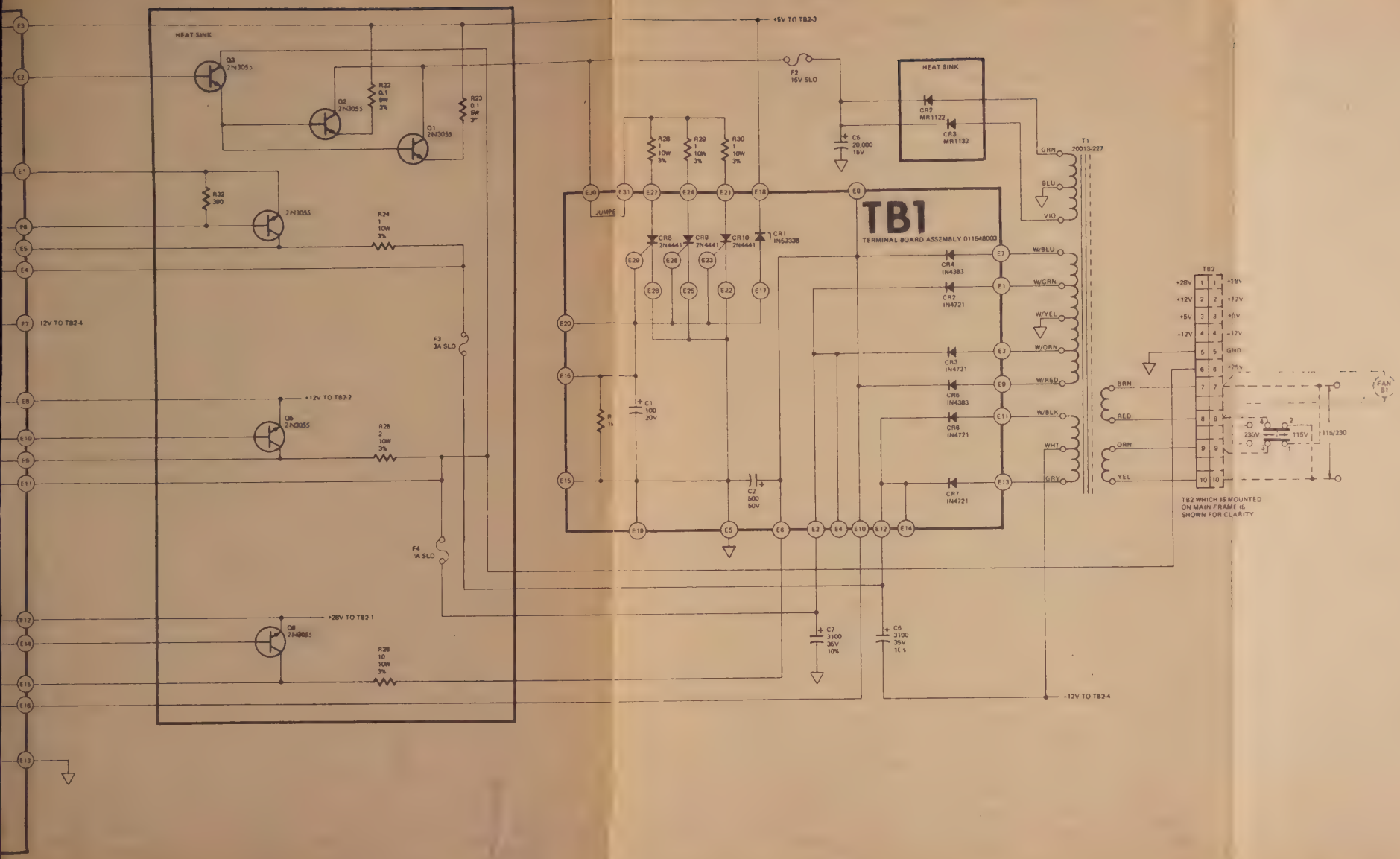

A35
A34
A31
CHASSIS REAR VIEW
HEAT SINK COMPONENTS


A33
01150403
TB1
01164803
F1
F2
F3
F4
TB2


A33
POWER SUPPLY ASSEMBLY 01150403
+12V
+12.V
-12V
5V
+5.0V


TB1
TERMINAL BOARD ASSEMBLY 01164803
JUMPER
SPARE


A33
POWER SUPPLY ASSEMBLY 01150403



REVISIONS						
REV	ECO	S/N	DESCRIPTION	DATE	MFGR	APPD
A		067	REDRAWN	6-74		
B	2283		Q1-Q3 WERE 40636, Q4-Q6 WERE 2N3792.	4-76		

NOTES: UNLESS OTHERWISE INDICATED:

1. (a) RESISTANCE SHOWN IN OHMS.
   (b) RESISTORS ARE 1/4W, ±5%.
   (c) CAPACITANCE SHOWN IN MICROFARADS.
   (d) CAPACITORS @ 50V, +80 -20%
2. FACTORY SELECT WITH TYPICAL VALUE SHOWN

HIGHEST REF DESIG USED
C17
CR10
E31
F4
Q15
R40
TB2

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SPECTRAL DYNAMICS CORPORATION OF SAN DIEGO

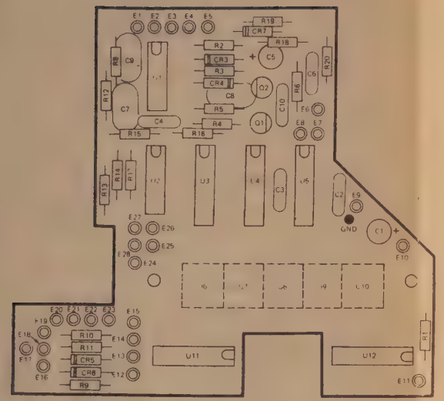
DRAWN	L. SAUER	8-74
DESIGNER		
CHECKED		
ENGINEER		
APPROVED		

TITLE: SCHEMATIC/COMPONENT LAYOUT POWER SUPPLY ASSEMBLY 01398001

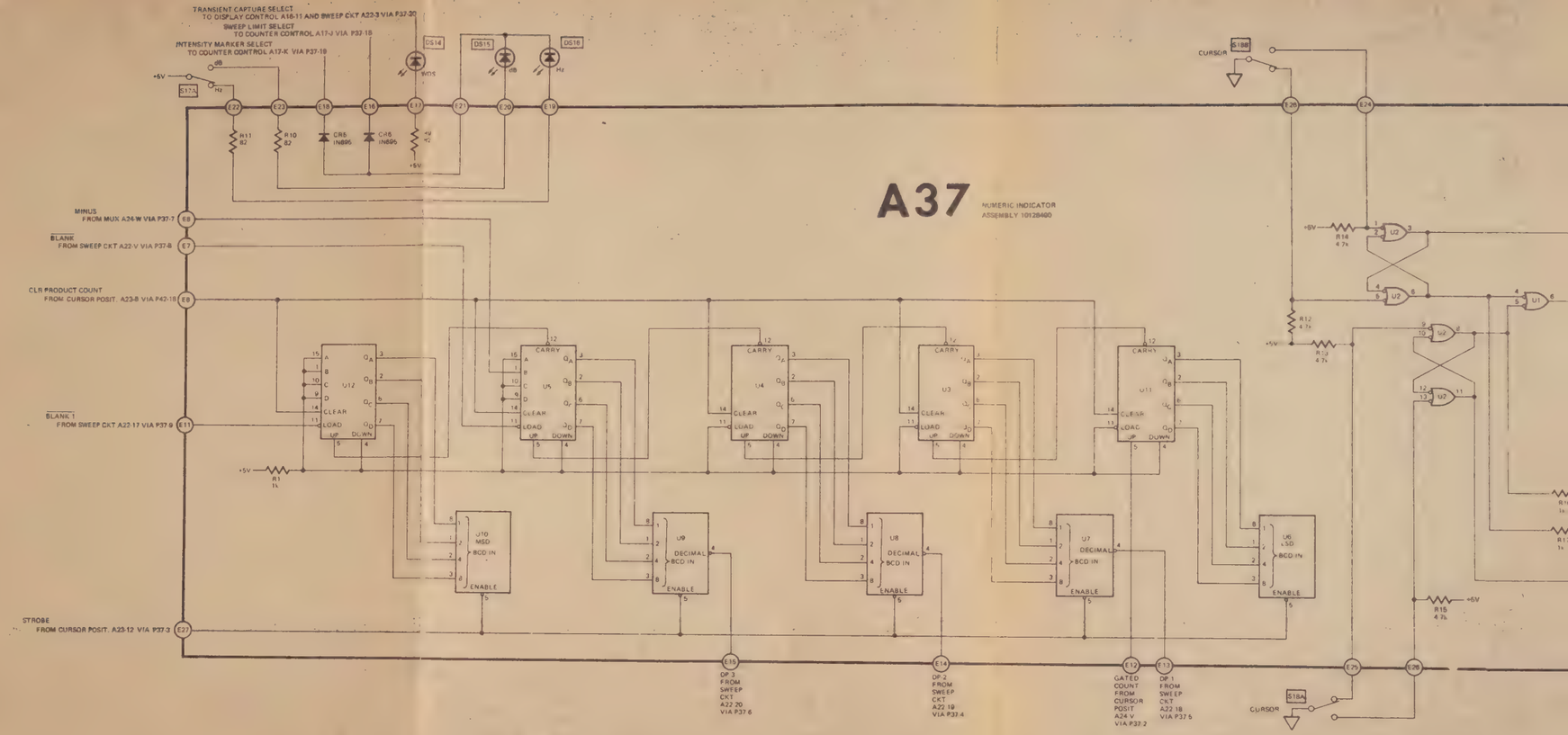
A33

MODEL	SIZE	DRAWING NO	REV
SD301D-C		10186300	B

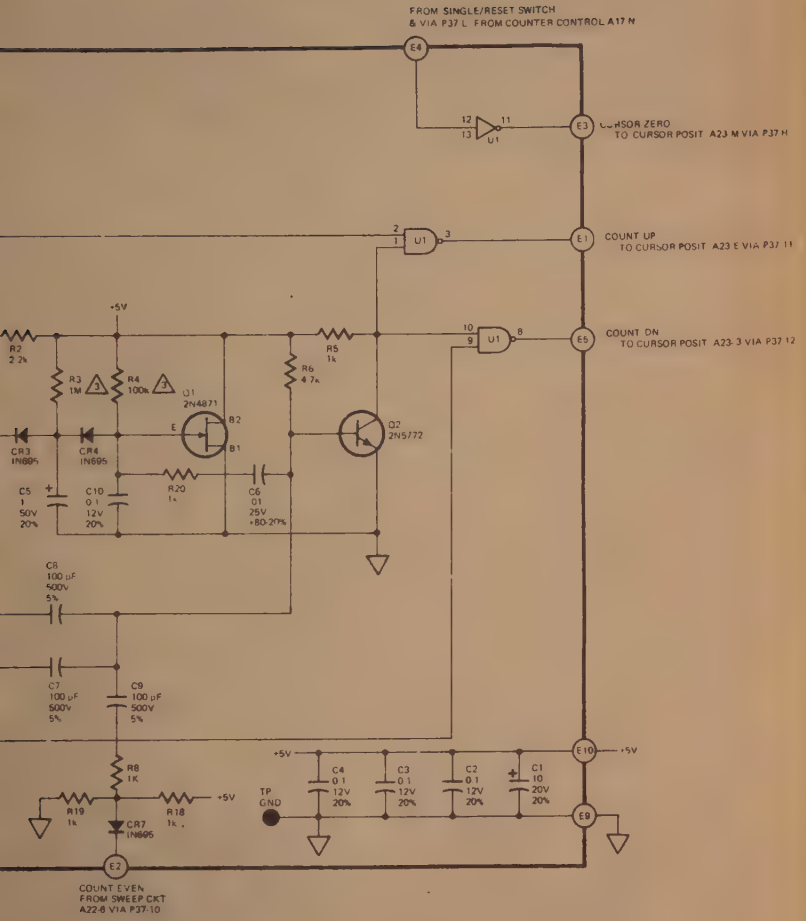
SCALE | SHEET 1 OF 1

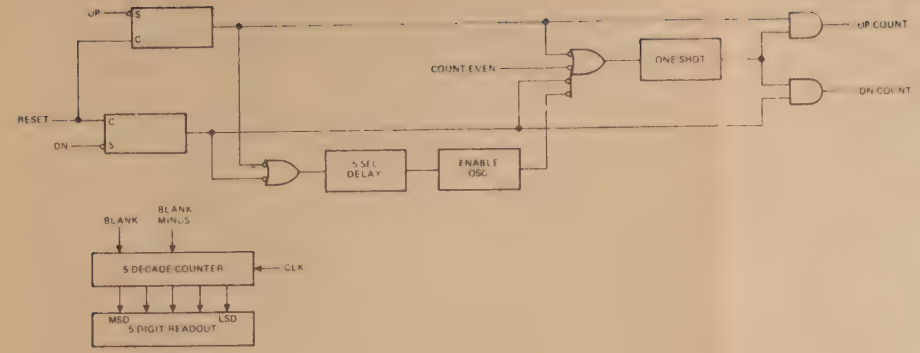


A37 NUMERIC INDICATOR ASSEMBLY 10128400



REVISIONS						
REV	ECO	S/N	DESCRIPTION	DRAFT	CHECK	APP
B	–		REDRAWN	L S 8-74		





NOTES: UNLESS OTHERWISE INDICATED:

1. (a) RESISTANCE SHOWN IN OHMS.
   (b) RESISTORS ARE 1/4W, ±5%.
   (c) CAPACITANCE SHOWN IN MICROFARADS.
2. SYMBOL ▭ INDICATES FRONT PANEL LOCATION.
3. ⚠ FACTORY SELECT WITH TYPICAL VALUE SHOWN.

INTEGRATED CIRCUITS				
REF DESIG	PART NO	PWR PINS GND	PWR PINS VCC	UNUSED CIRCUITS
U1,U2	SN7400N	7	14	NONE
U3,U4,U5,U11 & J12	SN74192N	8	16	NONE
U6,U10	5082 7300	7	8	NONE

HIGHEST REF DESIG USED
C10
CR7
E27
Q2
R20
U12

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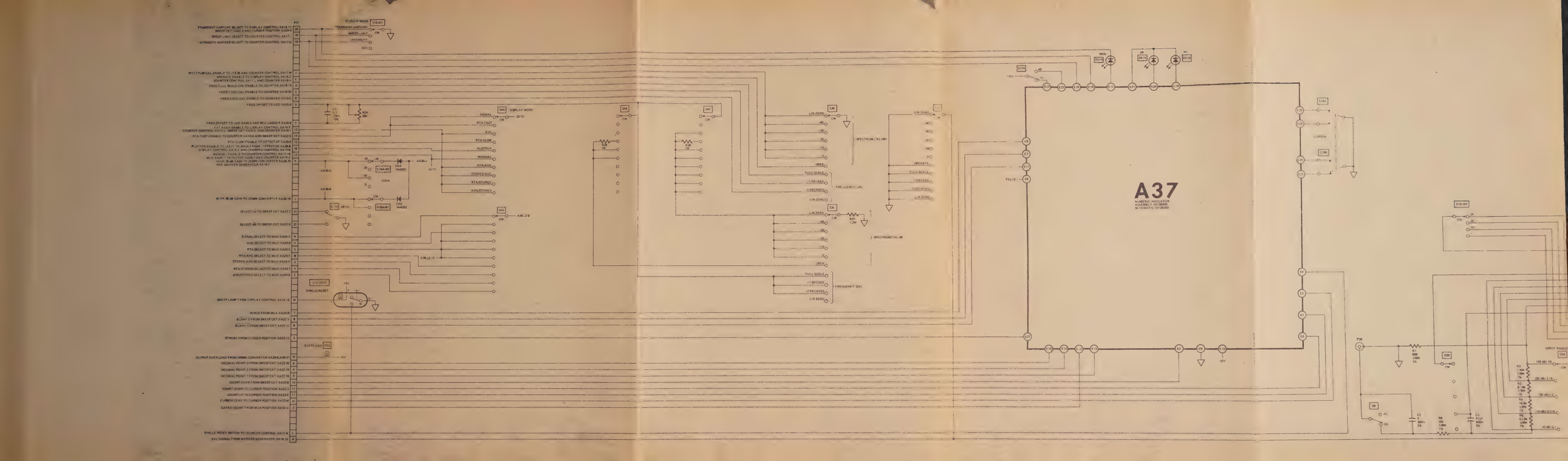
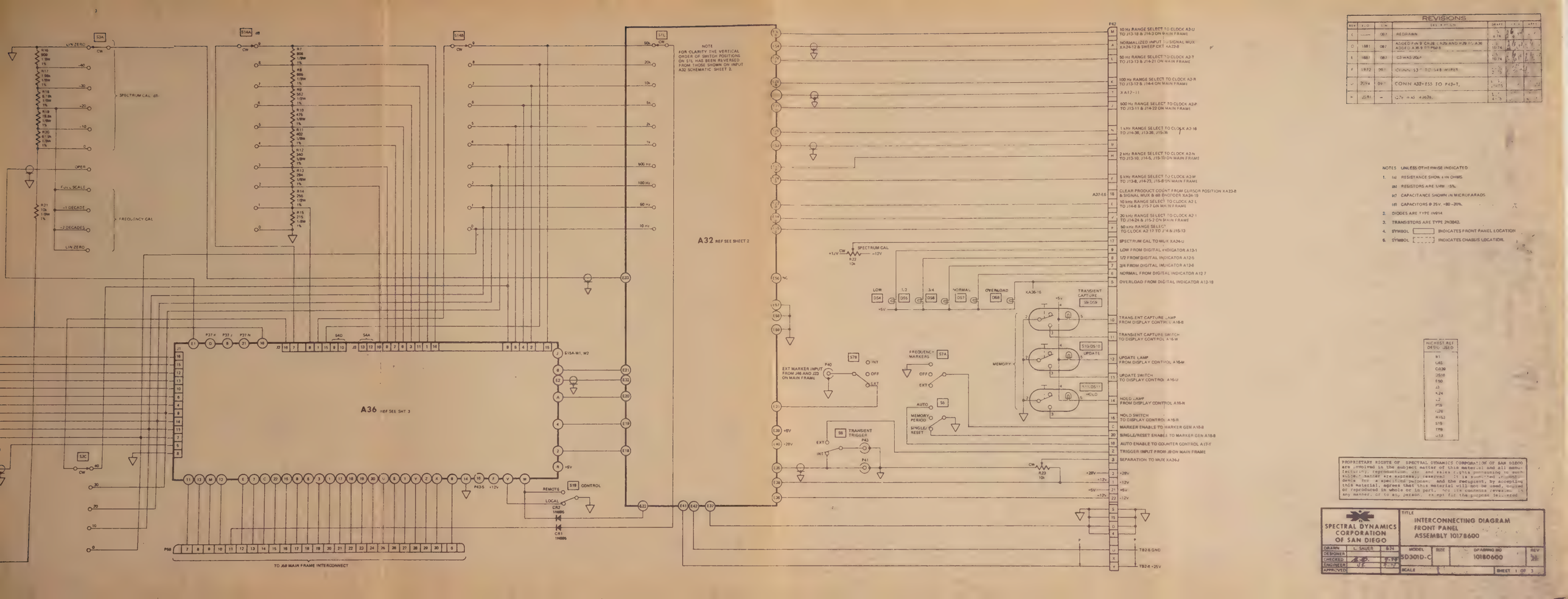
SPECTRAL DYNAMICS CORPORATION OF SAN DIEGO

TITLE: SCHEMATIC/COMPONENT LAYOUT
NUMERIC INDICATOR
ASSEMBLY 10128400
A37

DRAWN	L. SAUER	8-74
DESIGNER		
CHECKED		
ENGINEER		
APPROVED		

MODEL	SIZE	DRAWING NO	REV
SD301D-C		10186400	B
SCALE		SHEET 1 OF 1	


A37
NUMERIC INDICATOR
ASSEMBLY 1015800
SCHEMATIC 1012000


A32 REF SEE SHEET 2
A36 REF SEE SHT 3
NOTE
FOR CLARITY THE VERTICAL ORDER OF SWITCH POSITIONS ON S1L HAS BEEN REVERSED FROM THOSE SHOWN ON INPUT A32 SCHEMATIC SHEET 2.
SPECTRUM CAL dB
FREQUENCY CAL
SPECTRUM CAL
TRANSIENT CAPTURE
TRANSIENT TRIGGER
FREQUENCY MARKERS
MEMORY
REMOTE
LOCAL
CONTROL
10 Hz RANGE SELECT TO CLOCK A2-U TO J13-10 & J14-3 ON MAIN FRAME
50 Hz RANGE SELECT TO CLOCK A2-T TO J13-13 & J14-21 ON MAIN FRAME
100 Hz RANGE SELECT TO CLOCK A2-R TO J13-12 & J14-4 ON MAIN FRAME
500 Hz RANGE SELECT TO CLOCK A2-P TO J13-11 & J14-22 ON MAIN FRAME
1 kHz RANGE SELECT TO CLOCK A2-16 TO J14-38, J13-36, J15-16
2 kHz RANGE SELECT TO CLOCK A2-N TO J13-10, J14-5, J15-10 ON MAIN FRAME
5 kHz RANGE SELECT TO CLOCK A2-M TO J13-8, J14-23, J15-8 ON MAIN FRAME
CLEAR PRODUCT COUNT FROM CURSOR POSITION XA23-8 & SIGNAL MUX & dB ENCODER XA24-15
10 kHz RANGE SELECT TO CLOCK A2-L TO J14-8 & J15-7 ON MAIN FRAME
20 kHz RANGE SELECT TO CLOCK A2-I TO J14-24 & J15-2 ON MAIN FRAME
50 kHz RANGE SELECT TO CLOCK A2-17 TO J14-6 J15-13
SPECTRUM CAL TO MUX XA26-U
LOW FROM DIGITAL INDICATOR A12-1
1/2 FROM DIGITAL INDICATOR A12-5
3/4 FROM DIGITAL INDICATOR A12-6
NORMAL FROM DIGITAL INDICATOR A12-7
OVERLOAD FROM DIGITAL INDICATOR A12-18
TRANSIENT CAPTURE LAMP FROM DISPLAY CONTROL A16-8
TRANSIENT CAPTURE SWITCH TO DISPLAY CONTROL A16-W
UPDATE LAMP FROM DISPLAY CONTROL A16-M
UPDATE SWITCH TO DISPLAY CONTROL A16-U
HOLD LAMP FROM DISPLAY CONTROL A16-N
HOLD SWITCH TO DISPLAY CONTROL A16-R
MARKER ENABLE TO MARKER GEN A18-8
SINGLE/RESET ENABLE TO MARKER GEN A18-8
AUTO ENABLE TO COUNTER CONTROL A17-Y
TRIGGER INPUT FROM J8 ON MAIN FRAME
SEPARATION TO MUX XA26-J
+28V
+12V
+5V
-12V
TB2-6 GND
TB2-6 +25V
TO J68 MAIN FRAME INTERCONNECT

REVISIONS						
REV	ECO	DWN	DESCRIPTION	DRAFT	CHK	APPD
C	----	DBJ	REDRAWN	8-74		
D	1881	DBJ	ADDED PIN 9 ON J28, J42 & J43 AND P28, P42 & P43 ADDED A 35.5 TYP PAD R	10-74		
E	1882	DBJ	C3 WAS 20uF	10-74		
F	1932	DBJ	CONN S3 TO J68 SAME AS J63	1-75		
G	2094	DBJ	CONN A32-ESS TO P43-7,	5-75		
H	2581	--	CHG MAS A3628.	1-77		

NOTES: UNLESS OTHERWISE INDICATED
1. (a) RESISTANCE SHOWN IN OHMS
   (b) RESISTORS ARE 1/4W ±5%
   (c) CAPACITANCE SHOWN IN MICROFARADS
   (d) CAPACITORS @ 25V, +80 -20%.
2. DIODES ARE TYPE 1N914
3. TRANSISTORS ARE TYPE 2N3842.
4. SYMBOL [ ] INDICATES FRONT PANEL LOCATION
5. SYMBOL [ ] INDICATES CHASSIS LOCATION.

HIGHEST REF DESIG USED
B1
C45
CR30
DS16
E50
J3
K24
L2
P59
Q28
R153
S19
TP8
U33

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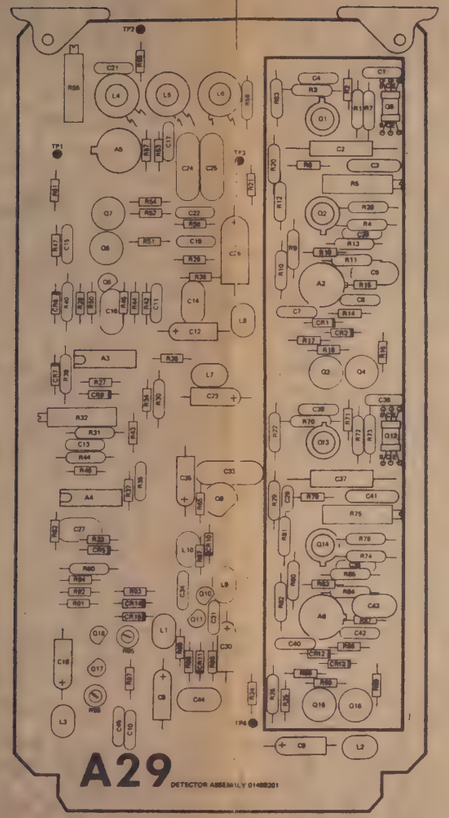
SPECTRAL DYNAMICS CORPORATION OF SAN DIEGO

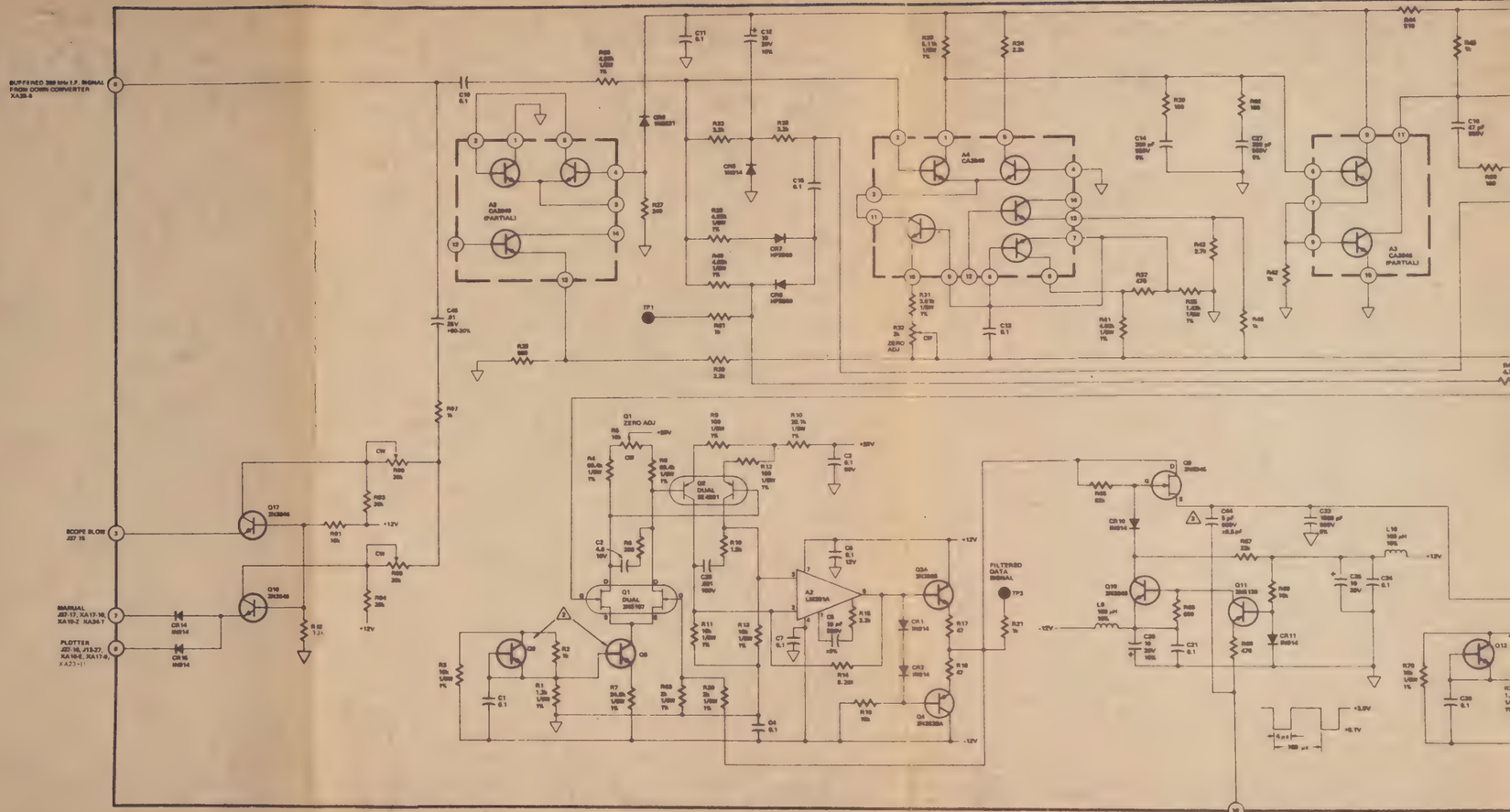
TITLE: INTERCONNECTING DIAGRAM FRONT PANEL ASSEMBLY 10178600

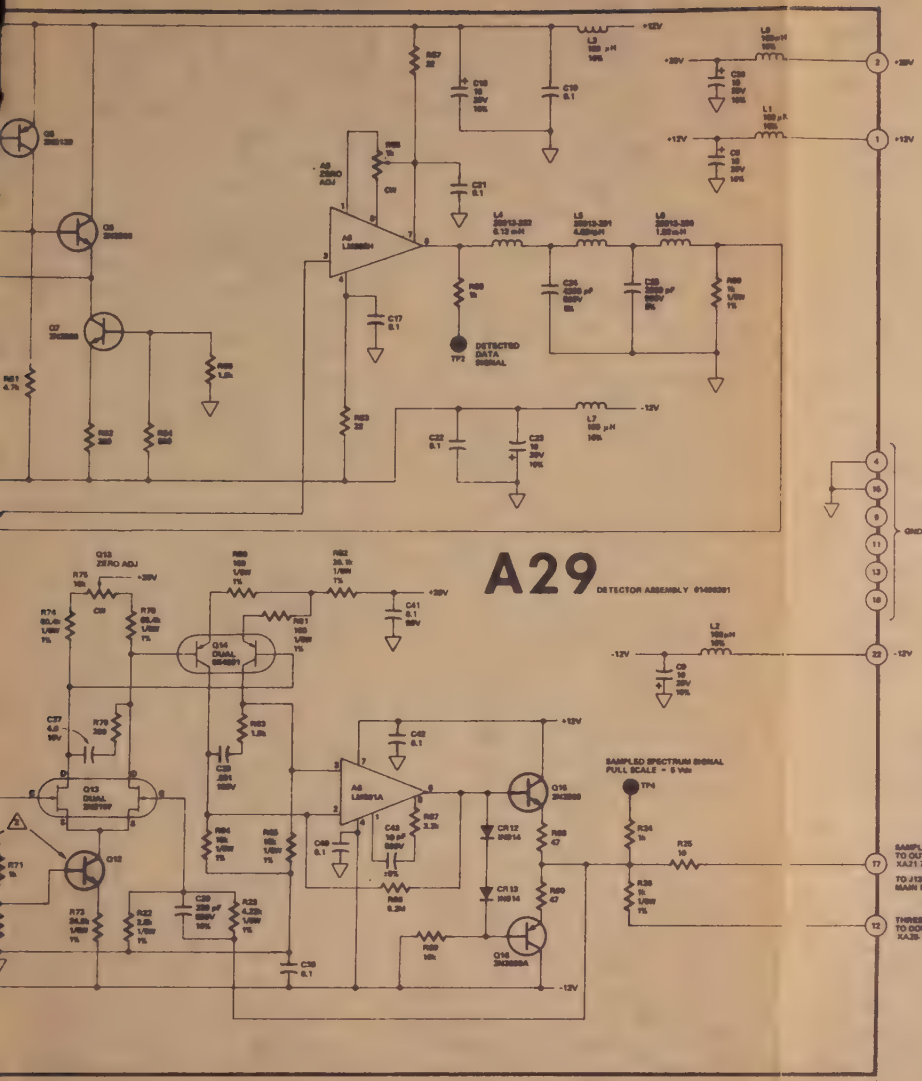
DRAWN	L. SAUER	8-74
DESIGNER		
CHECKED		
ENGINEER		
APPROVED		

MODEL: SD301D-C | SIZE: D | DRAWING NO: 10180600 | REV: H

SCALE: | SHEET 1 OF 3


A29
DETECTOR ASSEMBLY 01468201


BUFFERED 389 kHz I.F. SIGNAL FROM DOWN CONVERTER XA35-8
SCOPE BLOB J27-15
MANUAL J27-17, XA17-16, XA19-2 XA34-7
PLOTTER J27-16, J15-27, XA16-6, XA17-9, XA21-1-1
FILTERED DATA SIGNAL
SAMPLE PULSE FROM COUNTER CONTROL XA17-7
ZERO ADJ
+12V
-12V
+5V



REVISIONS					
REV	ECO	S/N	DESCRIPTION	DRAFT	CHK'D
A		087	REDRAWN	L.S. 7-74	
B	1896	087	R92 WAS 2K.	L.S. 2-75	

1. RESISTOR VALUES ARE IN OHMS, 1/4W, 5%.
2. MATCHED PAIR PER 28913-045 (2N3991A).
3. FACTORY ADJUST WITH TYPICAL VALUE SHOWN.

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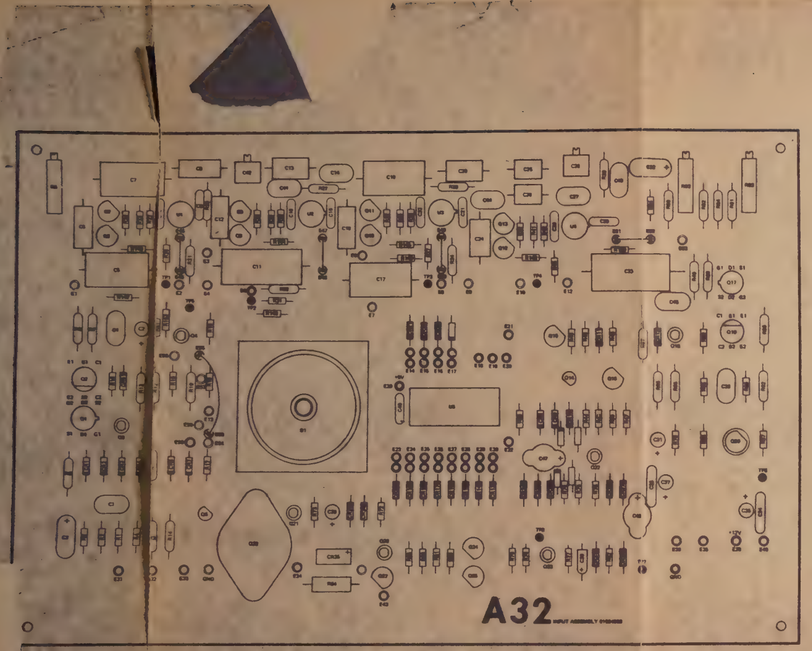
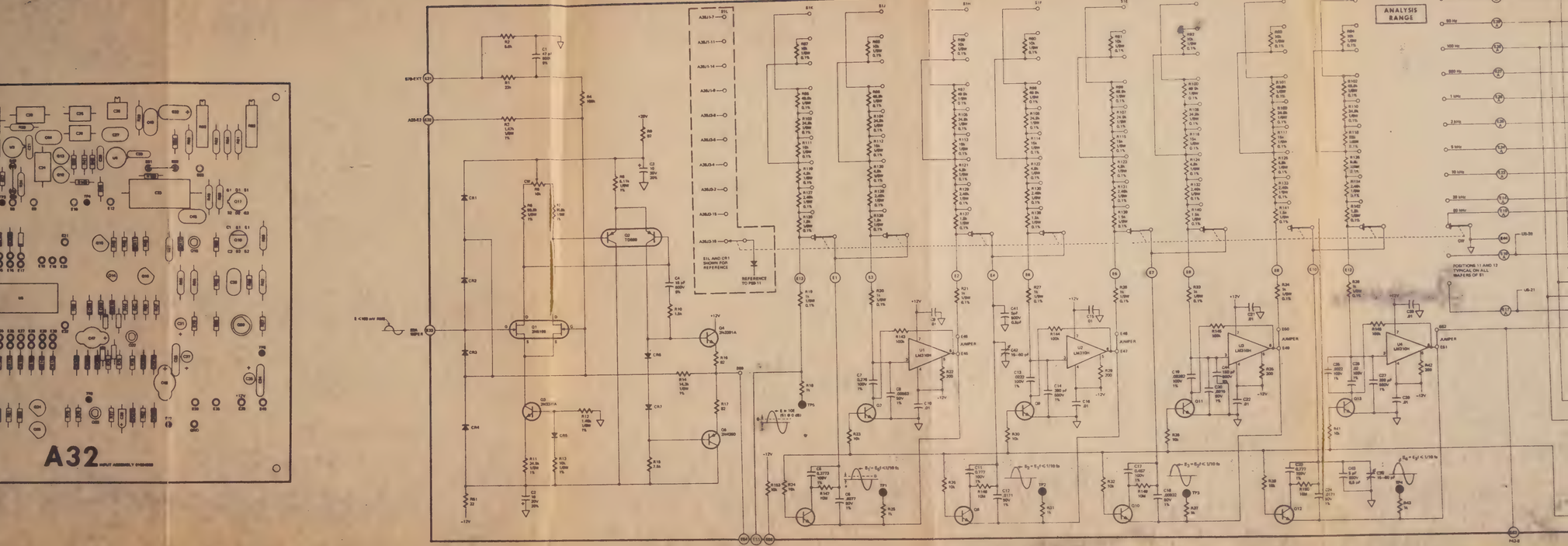
SPECTRAL DYNAMICS CORPORATION OF SAN DIEGO

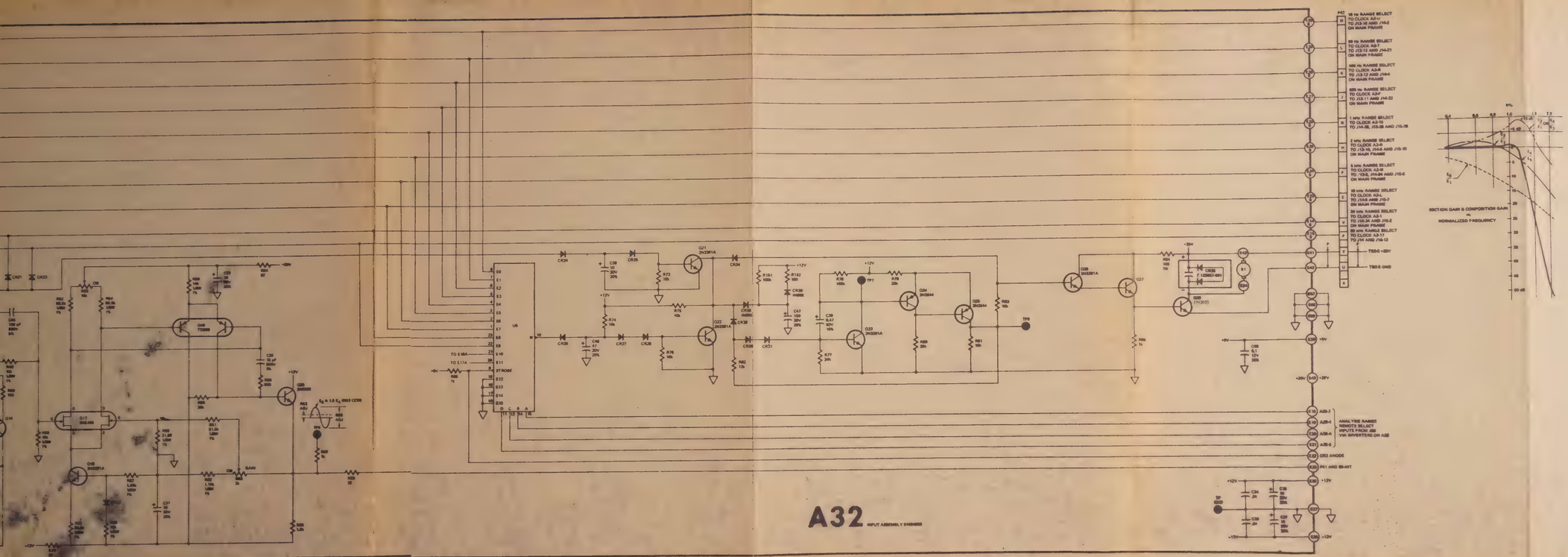
TITLE: SCHEMATIC/COMPONENT LAYOUT DETECTOR ASSEMBLY 01499201 A29

DRAWN	L. SAUER	7-74
DESIGNER		
CHECKED		8-74
ENGINEER		
APPROVED		

MODEL	SIZE	DRAWING NO.	REV
SD301D-C		10186200	B
SCALE		SHEET 1 OF 1	


A32


ANALYSIS RANGE
POSITIONS 11 AND 13 TYPICAL ON ALL BAZ INS OF S1
REFERENCE TO PSB-11
S1L AND CR1 SHOWN FOR REFERENCE


A32
INPUT ASSEMBLY 01084800
U5
TO E16A
TO E17A
ST ROSE
Q17 2N5485
Q18 2N5812A
Q19 2N5812A
Q20 2N5812A
Q21 2N3391A
Q22 2N3391A
Q23 2N3391A
Q24 2N3644
Q25 2N3644
Q26 2N3391A
Q27
Q28 TIP3055
Q33 2N3391A
CR25 1.25W/27-62V
TP1
TP2
TP3
TP4
TP5
TP6
TP7
TB5 +35V
TB6 GND
+35V
+12V
+9V
+20V
-20V
-12V
A39-2
A39-1
A38-4
A38-5
A38-6
DS2 ANODE
P41 AND B9-WHT
ANALYSIS RANGE REMOTE SELECT INPUTS FROM J28 VIA INVERTERS ON A28
16 Hz RANGE SELECT TO CLOCK A9-U TO J13-16 AND J14-3 ON MAIN FRAME
80 Hz RANGE SELECT TO CLOCK A9-T TO J13-13 AND J14-21 ON MAIN FRAME
160 Hz RANGE SELECT TO CLOCK A9-R TO J13-12 AND J14-4 ON MAIN FRAME
320 Hz RANGE SELECT TO CLOCK A9-P TO J13-11 AND J14-22 ON MAIN FRAME
1 kHz RANGE SELECT TO CLOCK A9-N TO J14-39, J13-38 AND J15-19
2 kHz RANGE SELECT TO CLOCK A9-K TO J13-16, J14-6 AND J15-16 ON MAIN FRAME
5 kHz RANGE SELECT TO CLOCK A9-H TO J13-5, J14-24 AND J15-5 ON MAIN FRAME
10 kHz RANGE SELECT TO CLOCK A9-L TO J14-8 AND J15-7 ON MAIN FRAME
20 kHz RANGE SELECT TO CLOCK A9-1 TO J15-24 AND J15-2 ON MAIN FRAME
80 kHz RANGE SELECT TO CLOCK A9-17 TO J14 AND J15-13
SECTION GAIN & COMPOSITION GAIN vs. NORMALIZED FREQUENCY

REVISIONS						
REV	ECO	S/N	DESCRIPTION	DRAFT	CHK'D	APP'D
			SEE SHEET 1			

INTEGRATED CIRCUITS				
REF DESIG.	PART NO.	PWR PINS GND	PWR PINS VCC	UNUSED CIRCUITS
U5	SN74193N	12	34	NONE

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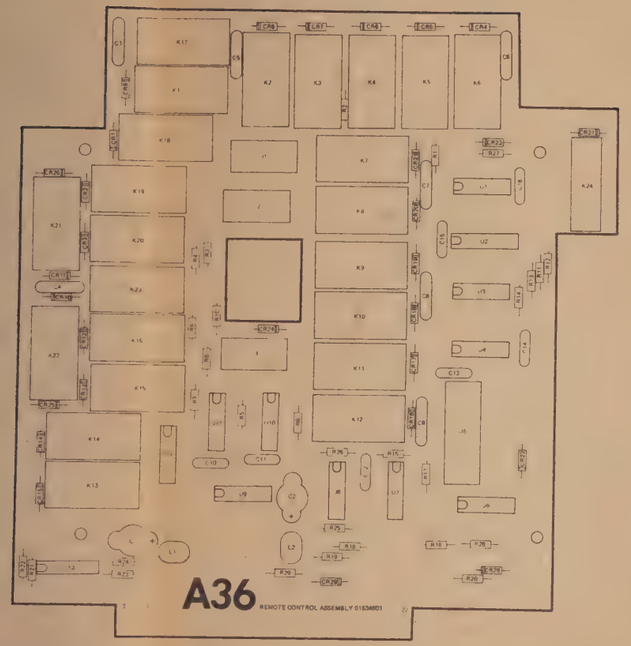
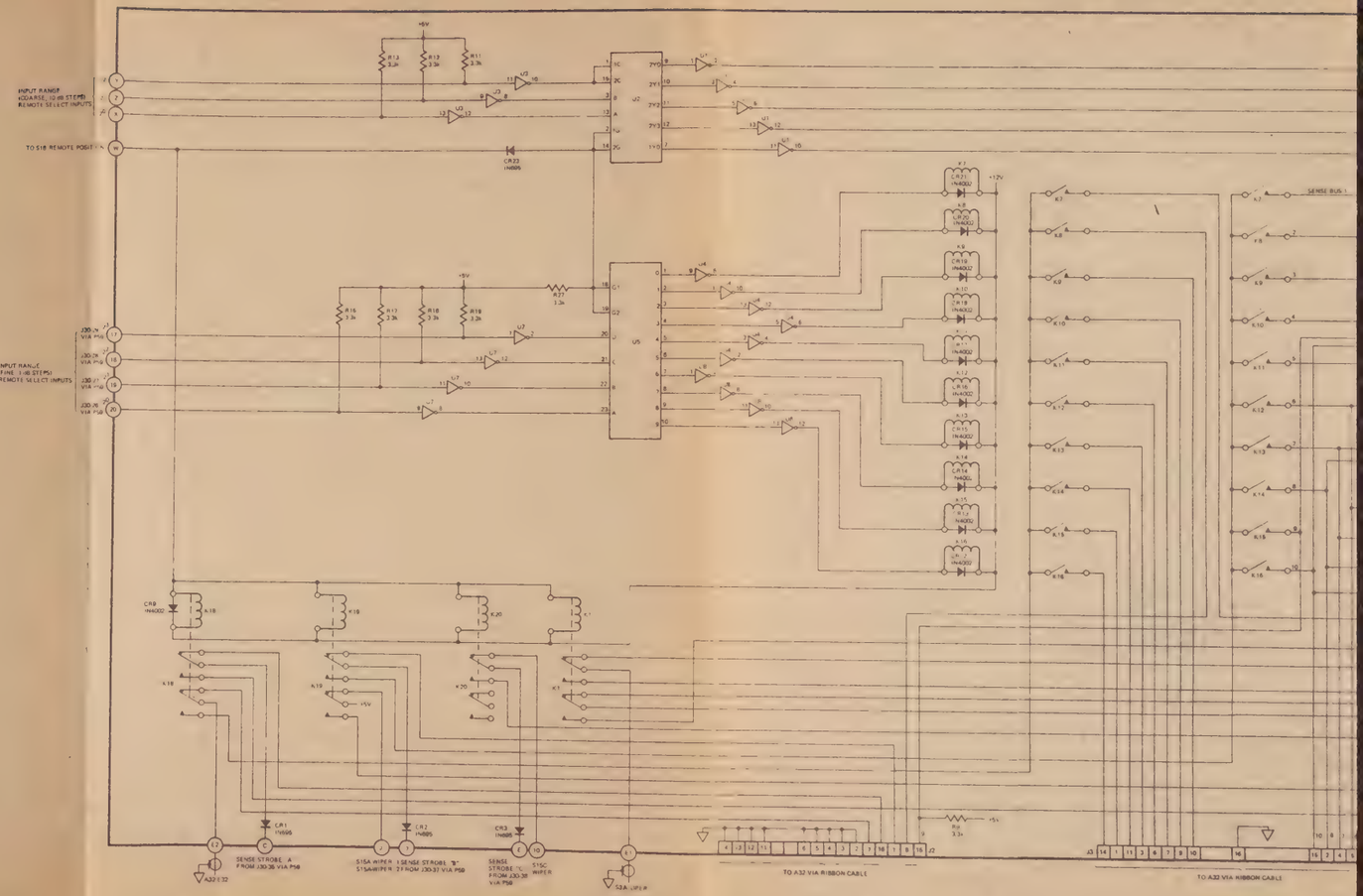
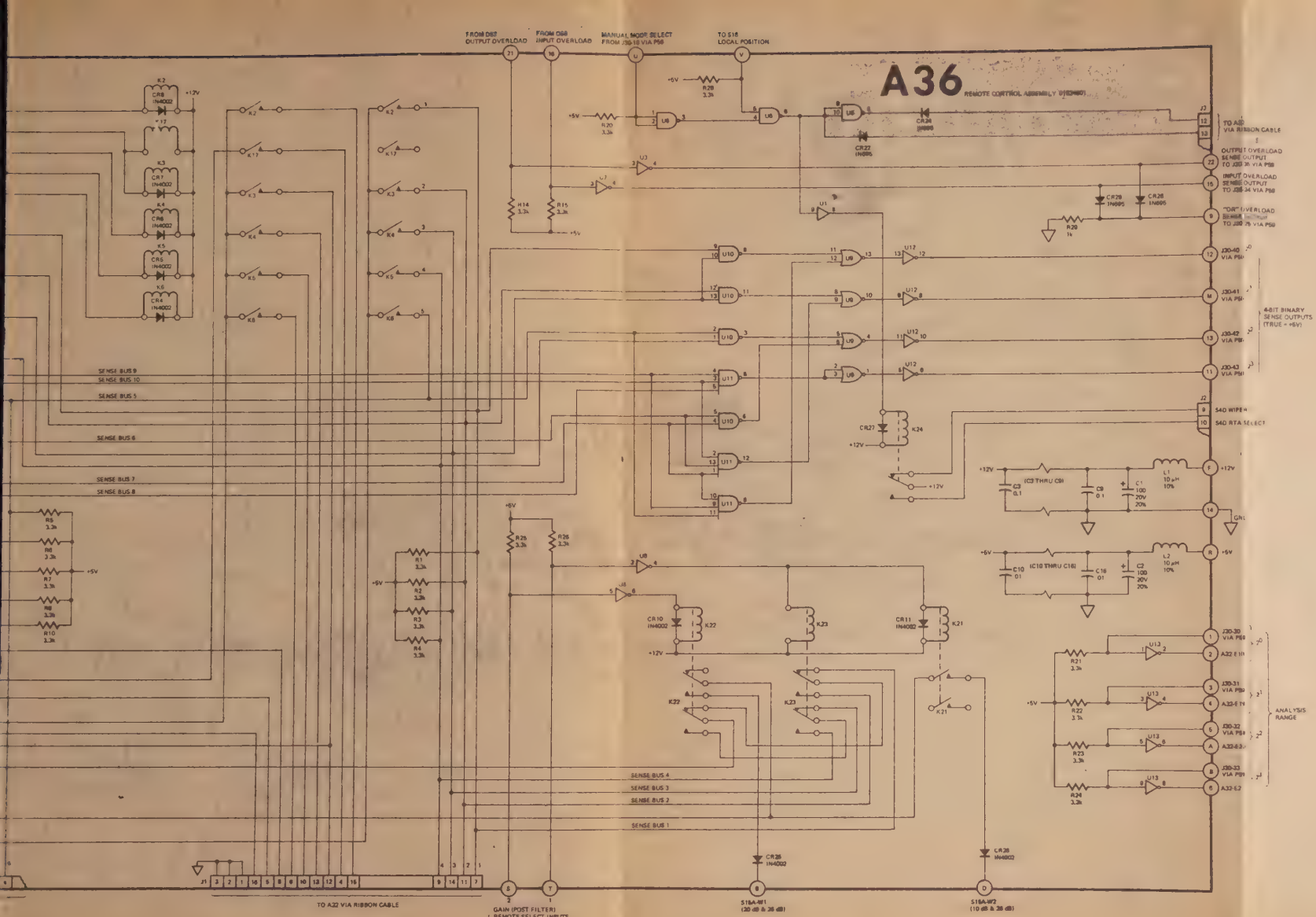
SPECTRAL DYNAMICS CORPORATION OF SAN DIEGO		TITLE: INTERCONNECTING DIAGRAM FRONT PANEL ASSEMBLY 10178400		A32
DRAWN: L. ROSE 1-3-75	MODEL: SD 301RD-C	SIZE: D	DRAWING NO.: 10180400	REV:
CHECKED:	SCALE:		SHEET 3 OF 3	



A36 REMOTE CONTROL ASSEMBLY 01534801


INPUT RANGE (COARSE, 10 dB STEPS) REMOTE SELECT INPUTS
TO S1B REMOTE POSITION
INPUT RANGE (FINE, 1 dB STEPS) REMOTE SELECT INPUTS
+5V
+12V
-15V
SENSE BUS
SENSE STROBE "A" FROM J30-36 VIA P5B
S1A WIPER
SENSE STROBE "B" FROM J30-37 VIA P5B
SENSE STROBE "C" FROM J30-38 VIA P5B
S1C WIPER
TO A32 VIA RIBBON CABLE
TO A32 VIA RIBBON CABLE



REVISIONS					
REV	ECO	S/N	DESCRIPTION	DRAFT	CHK'D APP'D
			SEE SHEET 1		

REF DESIG	PART NO	PWR PINS GND	PWR PINS VCC	UNUSED CIRCUITS
U1,U4,U8	SN7407N	7	14	NONE
U2	SN74166N	8	16	NONE
U3,U7,U12 & U13	SN7404N	7	14	U3-A,U7-C
U5	SN74154N	12	24	NONE
U6,U10	SN7400N	7	14	U6-D
U9	SN7402N	7	14	NONE
U11	SN7410N	7	14	NONE

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SPECTRAL DYNAMICS CORPORATION OF SAN DIEGO

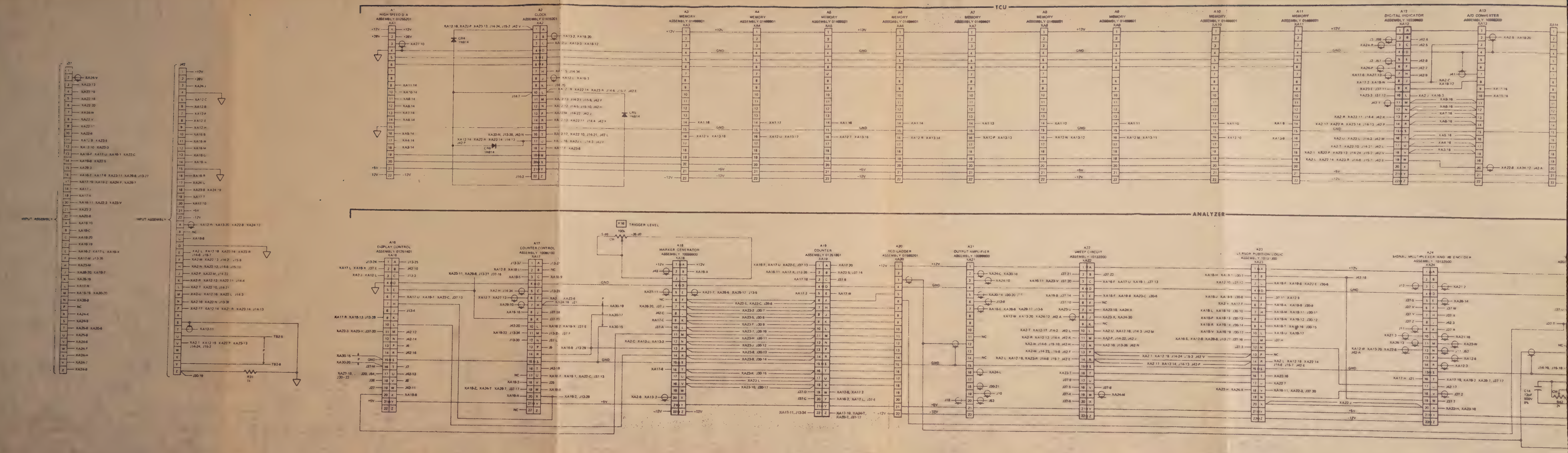
TITLE: INTERCONNECTING DIAGRAM FRONT PANEL ASSEMBLY 10178600

A36

DRAWN	C. SAUER	8-74
DES'GNER		
CHECKED		8-74
ENGINEER		9-74
APPROVED		

MODEL: SD3010-C | SIZE | DRAWING NO: 10180600 | REV: H

SCALE | SHEET 3 OF 3


TCU
ANALYZER
A1 HIGH SPEED D A ASSEMBLY 01266201 XA1
A2 CLOCK ASSEMBLY 01416301 XA2
A3 MEMORY XA3
A4 MEMORY XA4
A5 MEMORY XA5
A6 MEMORY XA6
A7 MEMORY XA7
A8 MEMORY XA8
A9 MEMORY XA9
A10 MEMORY XA10
A11 MEMORY XA11
A12 DIGITAL INDICATOR XA12
A13 A/D CONVERTER XA13
XA14
J37
J42
INPUT ASSEMBLY
INPUT ASSEMBLY
A16 DISPLAY CONTROL ASSEMBLY 01251401 XA16
A17 COUNTER CONTROL ASSEMBLY 10080100 XA17
R18 TRIGGER LEVEL
A18 MARKER GENERATOR XA18
A19 COUNTER ASSEMBLY 01251801 XA19
A20 NCD LADDER ASSEMBLY 01580201 XA20
A21 OUTPUT AMPLIFIER XA21
A22 SWEEP CIRCUIT ASSEMBLY 10133200 XA22
A23 CURSOR POSITION LOGIC ASSEMBLY 10131300 XA23
A24 SIGNAL MULTIPLEXER AND dB ENCODER ASSEMBLY 10133500 XA24
GND
+12V
+5V
-12V
CR4 1N914
CR5 1N914
CR6 1N914
R31 1k
C14 12pF 500V 5%

17. Observe that memory is loaded over 6-2/3 divisions with the data level and zero for 3-1/3 divisions.

18. Repeat steps 15, 16, and 17 with the CURSOR location set to 500; observe memory is loaded with data level over 3-1/3 divisions.

19. Repeat with the CURSOR location set to 000 and observe that memory is loaded with all zeros.

n. Check modes from external inputs as follows:

1. Set TRANSIENT TRIGGER control to EXT. Set CURSOR location to 999.

2. Apply a 2.5V positive pulse to TRANSIENT CAPTURE (J8); TRANSIENT CAPTURE HOLD control/indicator will light.

3. Momentarily apply a full scale signal to the input (J45). Nothing should occur until a 2.5V pulse is applied at TRIG INPUT (J9). Apply the pulse to J9 and observe that transient capture occurs; TRANSIENT CAPTURE control/indicator goes out, HOLD control/indicator lights, and memory is filled with data level over 6-2/3 divisions.

4. Check out-of-band input signal OVERLOAD. Set ANALYSIS RANGE control to 10 kHz. Apply 20 kHz signal at +12 dB at SIGNAL INPUT (J45). The OVERLOAD indicator on the front panel should light. The NORMAL, 3/4, 1/2, and LOW indicators should not be lighted. Change SIGNAL INPUT to +11 dB, OVERLOAD indicator should go OFF.

This concludes the operational checkout for the Real Time Analyzer Unit.

4.4 PARTS REPLACEMENT

Except for some special SDC specification-controlled parts listed in Table 4-2, which must be ordered from Spectral Dynamics Corporation, standard electronic parts have been used throughout the instrument. Although standard, the pilot lamp bulbs, switches, fuses and power cord have been included to aid in their replacement. Spectral Dynamics Corporation maintains a complete stock of all parts and complete printed circuit card assemblies used in this instrument.

When ordering a replacement part or assembly, be sure to include the reference designation, the part number or manufacturer's designation, and a complete description; include also the instrument name, model number, and serial number.

Table 4-2. Special Replaceable Parts List

Reference Designator	Description	Part Number/ Mfr. Designation
A1	Circuit Card, High-Speed D-A	01255201
A2	Circuit Card, Clock	01416201
A3–11	Circuit Card, Memory	01499601
A12	Circuit Card, Digital Indicator	10339600
A13	Circuit Card, A/D Converter	10208200
A16	Circuit Card, Display Control	01251401
A17	Circuit Card, Counter Control	10080100
A18	Circuit Card, Marker Generator	10098900
A19	Circuit Card, Counter	01251801
A20	Circuit Card, BCD Ladder	01580200
*A21	Circuit Card, Output Amplifier	10099800/10099801*
A22	Circuit Card, Sweep	10133200
A23	Circuit Card, Cursor Position	10131300
A24	Circuit Card, Display Multiplexer	10133500
A25	Circuit Card, 18–23 MHz VCO	01544401

*Assembly 10099801 used for Squared Output "-6" Option.

Set GAIN control to X3.16 (10 dB); Output OVERLOAD indicator should light. Return GAIN control to X1.

d. Set DISPLAY MODE control to MANUAL (position 5); intensity marker should be near the same vertical graticule line as the fundamental (See Figure 4-4.) Adjust FREQUENCY-CAL potentiometer to ensure intensity marker is at peak amplitude.

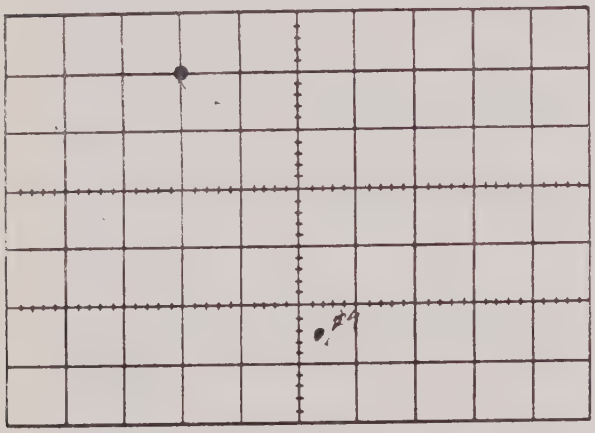
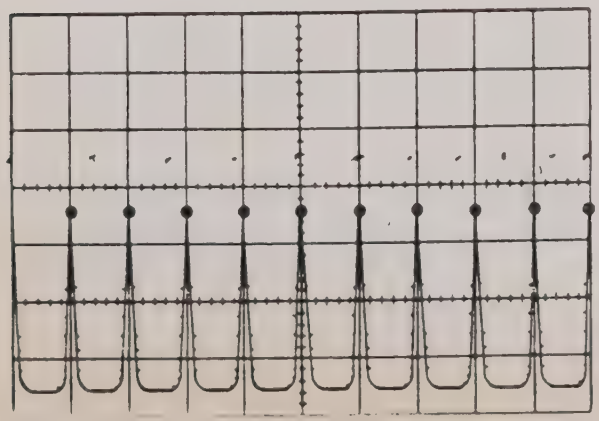


Figure 4-4. Intensity Marker at Peak of Calibration Signal Fundamental.

e. Set front-panel controls as follows:

DISPLAY MODE to RTA FAST (Position)
OPER/CAL to OPER
FREQUENCY MARKERS to INT
CURSOR MODE to INTENSIFY

Observe 10 intensity markers, one on top of each frequency marker. See Figure 4-5.



f. Set front-panel controls as follows:

FREQUENCY MARKERS to OFF
OPER/CAL to SPECTRUM CAL, 0 dB
ANALYSIS RANGE to 10 Hz

After approximately 50 seconds, the display should return to that shown in Figure 4-3 (except that 10 frequency markers are not present). Select each ANALYSIS RANGE setting up to 50 kHz; for each setting, wait the indicated MEMORY PERIOD SEC; and verify that display is as shown in Figure 4-3.

g. Check output linearity as follows:

1. Move Cursor intensity dot to peak of calibration signal. Set Hz/dB control to dB. Adjust SPECTRUM-CAL for 00.0 dB.

2. Set OPER/CAL control to SPECTRUM-CAL −10; verify a 10 dB decrease in output (1 division down on oscilloscope).

3. Set GAIN control to X3.16 (10 dB); verify a 10 dB increase in output (±0.5 dB).

4. Set OPER/CAL control to −20 dB; verify a 10 dB decrease in output.

5. Set GAIN control to X10; verify a 10 dB increase in output (±0.5 dB).

6. Set OPER/CAL control to −30 dB; verify a 10 dB decrease in output.

7. Set GAIN control to X20; verify a 6 dB ±1 dB increase in output (0.6 division on oscilloscope).

8. Set GAIN control to X1; verify a 26 dB decrease from X20 setting of Step 7.

9. Set OPER/CAL control to −40 dB; verify a 10 dB decrease in output.

10. Set OPER/CAL control to LIN ZERO; verify zero output. (Approximately −55 dB.)

11. Return OPER/CAL control to SPECTRUM-CAL 0 dB.

h. Check INPUT RANGE fine attenuator operation; verify a 1 dB ±0.3 dB (0.1 division on oscilloscope) change for each setting, 1, 2, 3, 4, 5, 6, 7, 8, 9. Return INPUT RANGE fine attenuator control to 0/CAL.

i. Set FREQUENCY MARKERS control to INT. Press and hold in the MEMORY HOLD control/indicator while setting OPER/CAL control to OPER; then release MEMORY HOLD control/indicator; indicator should remain lighted. The calibration signal is now held in memory.

j. Check operation of Sweep Initiation Control functions as follows:

1. Set DISPLAY MODE control to RTA SLOW (Position 3). Note increased flicker on output display.

2. Set DISPLAY MODE control to PLOTTER (Position 4).

3. Place Sweep Initiation Control to SINGLE RESET; SINGLE RESET control/indicator will light and sweep trace will start moving across the oscilloscope or,

4. Press SINGLE RESET control/indicator; indicator goes out and sweep track resets to extreme left and stays.

5. Press SINGLE RESET control/indicator again; indicator lights and sweep slowly scans outline of calibration signal and frequency markers. (dB readout is not valid.)

k. Set DISPLAY MODE control to MANUAL (Position 5), ANALYSIS RANGE to 10k. Hz/dB control to Hz; sweep trace will reset to the left. Move the Cursor address to 1000, 2000, and 3000; the intensity marker will appear at the top of the first frequency marker, the second marker, and then the calibration signal, in that order.

l. Check the operation of the SWEEP LIMIT mode:

1. Set DISPLAY MODE control to RTA FAST (Position 1), Sweep Initiation control to AUTO, CURSOR MODE control to SWEEP LIMIT, and Cursor address to 3000. Observe that only 30 percent of sweep is present on display oscilloscope.

2. Change Cursor address in increments of 100 from 3100 to 3900. For each setting, verify that sweep length increases proportionally in 1 percent increments.

3. Change Cursor address in increments of 20 between 3900 and 4000. Verify sweep length increases proportionally. Set CURSOR MODE control to OFF and push SINGLE RESET control/indicator.

m. Check out TRANSIENT CAPTURE mode as follows:

1. Set FREQUENCY MARKERS control to OFF, and ANALYSIS RANGE to 5k.

2. Set TRANSIENT TRIGGER control to INT.

3. Apply a full scale input signal to SIGNAL INPUT connector (J45).

4. Turn INPUT RANGE fine attenuator to -9 dB.

5. Turn TRIGGER LEVEL control (pot) to -5 dB clockwise.

6. Push TRANSIENT CAPTURE control/indicator.

7. Decrease INPUT RANGE Fine attenuator setting in 1 dB steps and verify that the unit goes into hold for a signal level greater than -5 dB (e.g., -3 dB).

8. Turn TRIGGER LEVEL control to -35 dB.

9. Attenuate input signal 40 dB and turn the INPUT RANGE fine attenuate to -9 dB.

10. Push TRANSIENT CAPTURE control/indicator.

11. Verify that input will not trigger on noise.

12. Increase input signal in 1 dB steps and verify that input will trigger on a signal smaller than -35 dB (e.g., -37 dB).

13. Return INPUT RANGE Fine attenuator to 0/CAL, INPUT RANGE to 1 Vrms.

14. Monitor MEMORY output (J22), trigger on MEMORY SYNC (J21), set oscilloscope time base to 10 μs per division. Memory contents are now displayed on the oscilloscope with the beginning of memory at the extreme right and the end of memory ten divisions to the left.

15. Set the CURSOR MODE control to TRANSIENT CAPTURE, CURSOR location to 999 and press the TRANSIENT CAPTURE control/indicator.

16. Momentarily apply a full scale signal to the input and observe the following sequence of events: TRANSIENT CAPTURE control/indicator goes out, UPDATE control/indicator momentarily lights and goes out, and then HOLD control/indicator lights.